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SEWAGE TREATMENT—ELECTRICAL VERSUS CHEMICAL.

IN the trials made during last summer at the Salford and Pendleton Sewage Works, the electrical treatment of sewage was tested alongside the processes of the International Sewage Purification Company, the Barry Patent Company, and that of Messrs. Spence and Sons. It is intended to discharge the sewage after treatment into the Ship Canal, and it is therefore essential to obtain an effluent which is not only inoffensive on leaving the sewage works but which will not undergo any subsequent putrifactive change. Two chemists working independently were appointed to pronounce on the character of the effluents and, generally, on the efficiency of the various processes. An electrical engineer reported on the working of the plant put down for the trial of the electrical process, and estimates were prepared by the engineers employed by the Salford Corporation of the cost which the various systems would involve.

Two of the four competitors are now practically out of the running, the only difficulty being to decide between the relative merits of the Electrical and International systems of treatment, both of which alike for efficiency and cheapness prove to be preferable to the others. The process of the Electrical Purification Company was as follows:—The current was provided by a Charlesworth and Hall dynamo (50 volts 50 amperes), driven direct by a small tandem compound engine at about 600 revolutions with 100 lbs. steam pressure. The current was conveyed by copper strips to the iron electrodes. These were placed in an inclined brick channel or shoot 90 feet long, through which the sewage flowed at the rate of 2,300 gallons per hour. The channel was divided into 28 cells, in each of which were 13 plates 4 feet × 2 feet 8 inches × ½ inch, presenting an effective surface of 256 square feet per cell. The sections were connected in series in the same way as in ordinary accumulators, viz., positive and negative alternately, and the direction of the current was reversed at intervals of from 8 to 12 hours, to prevent the back E.M.F. generated in the cells from becoming too great. A brick partition extending below the surface of the liquid, and another rising from the bottom between the intermediate sections, served to ensure the proper circulation of the sewage. From the result of the trials, it is calculated that to deal with the ten million gallons per diem of the Salford and Pendleton sewage 334 electrical H.P. would be required. Assuming the E.H.P. to be 80 per cent. of that indicated by the engine, an engine yielding 417·6 I.H.P. would be needed. The weight of iron consumed would be 674½ tons per annum. From the channel or shoot the sewage flowed into five tanks, containing altogether 16,500 gallons, and thence to the filters. The *rationale* of the purifying process which goes on is explained by one of the consulting chemists as follows:—Ferrous oxide (Fe O) formed on the anode is dissolved off at once by the action of the sewage matter, then oxidised by the air to ferric oxide (Fe_2 O_3), which is again reduced by the sewage matter; the ferric oxide acting as a carrier for the oxygen of the air. Finally, ferric oxide is left in a very finely divided state, difficult to remove by filtration. The ferric oxide imparts a brown colour to the effluent, but is in itself quite unobjectionable. According to the analyses of one of the chemists, the insoluble matter consists almost entirely of this ferric oxide, and if this is so, the subsidence and filtration might be dispensed with. This would effect an important economy, and would bring down the estimated cost of the electrical treatment nearly to a level with that of the International Company. However, the views of the second consulting chemist by no means agree with those of the first: the matter in suspension being, according to this authority, largely organic, and subsidence and filtration therefore absolutely necessary. It is an unfortunate circumstance that the complete disaccord throughout in the chemical evidence renders it difficult to judge of the relative efficiency of the two processes (electrical and international) in the matter of purification. Both undoubtedly worked in the experimental trials with great success, and the International Company, as is well known, have carried on their process for some years at Acton with, apparently, excellent results. The *precipitant* in this process is the material known as ferozone, in which, as in the electrical process, the real purifying agent is the iron which passes from the ferrous

to the ferric state, and back again to the ferrous under the successive action of the oxygen of the air and of the sewage matter. The special feature of the International system is, however, the employment of the material known as polarite in the filters. It is claimed that this material is efficient in the removal of organic matter. It is said to be prepared from black-band ironstone, which is heated for 24 hours in gas retorts, after which treatment it is found to be magnetite, and is said to contain a *magnetic oxide*. This magnetic oxide cannot, however, be the same as the mineral magnetite, commonly known as magnetic oxide of iron, since the latter is an actual magnet, whereas the material in polarite is attracted by *both* poles of the magnet, and does not itself attract unmagnetised iron. It does not appear to contain metallic iron, since it does not yield any hydrogen when treated with an acid. The analyses given of the polarite present great discrepancies, which it is hard to account for, except on the supposition that one or both of the analysts failed to obtain a representative sample. Not less divergent are the views expressed by these authorities on the efficiency of polarite as a purifying material, one of the chemists admitting its efficacy ; the other being altogether sceptical, and regarding it as so much inert material. One other point with regard to the polarite filtering beds requires further investigation. Supposing polarite to be really a purifying material, how long will it retain its efficiency, and how often will the beds require to be renewed ? This is a question which has an important bearing on the cost of the process. The engineer's estimate apparently makes no allowance for the possible wearing out of the material, perhaps owing to want of data. Should it be found that the life of the polarite filter beds is a short one, it is conceivable that the balance of cost may turn in favour of the electrical process. With regard to the Electrical Company's process, the best and the worst is at any rate known, and there remains no such important outstanding question as that of the life of the filter beds employed by the International Company.

We turn now to the all-important estimates given of the cost of the two processes.

Electrical.

Iron electrodes 5,400 tons renewed every five years	£4,500
Labour	1,800
Coal for working engines	1,900
Depreciation and repairs	1,250
Steam engines, dynamos and works, £20,000 at 5 per cent.	1,000
Sand filters and works...	1,275
Sludge	2,070
Precipitation	902
Filtration	270
	£14,967

International.

Ferozone 7 grains per gallon, 1,630 tons at £2 10s. per ton	£4,075
Labour	1,800
Depreciation and repairs	150
Polarite, sand filters and other works, £25,000 at 5 per cent.	2,600
Sludge	2,250
Precipitation	462
Filtration	400
	£11,737

Looking at the estimate for "polarite, sand filters and other works," it will be seen how much depends on the question of the permanent efficiency of the polarite. The estimates for the Spence and Barry systems much exceed those given above (Spence £17,817, Barry £24,612) : we believe, however, that it is contemplated to give one of these another trial. Perhaps a satisfactory solution of the difficult question of the rival merits of the Electrical and International processes may be found if the Salford authorities decide to have experimental works erected and to conduct the two processes for themselves for a sufficient length of time ; the works being open for inspection and the collection of samples at all times to the engineering and chemical advisers appointed by the Corporation.

THE COST OF ELECTRICAL ENERGY.

RELIABLE data on the consumption of fuel and on the cost of producing a given quantity of electrical energy at central lighting stations is very scarce indeed. Young engineers have been and are apt to compute the item of fuel in the following way :—Since it is possible, with a first-rate engine, to produce an indicated horse-power for one hour with two pounds of good coal, and since the combined efficiency of an engine and dynamo may be over 80 per cent., therefore the electrical horse-power, or 746 watts, need not require more than 2·5 lbs. of fuel for its generation. Consequently, the Board of Trade unit of 1,000 watt hours would be produced by 3·35 lbs. of coal. This economical condition can only be reached in cases where the plant is working at full load, and that occurs in electric lighting for but a small fraction of the day. Electrical engineers in general should feel grateful to Mr. Crompton for the admirable paper which he presented to the Institution of Civil Engineers, on the 7th inst., entitled "The Cost of the Generation and Distribution of Electrical Energy." Mr. Crompton carefully analyses the wide difference between the "calculated" cost of energy and the figures attained in practice. The three items of cost, namely, material, labour, and upkeep, were influenced chiefly by the "load-factor," the design and arrangement of plant, and the local cost of material and labour.

The name "load-factor" expresses the relation which the actual output of a given plant bears to what would be its output if it were worked continuously at full load. For instance, if in a lighting station the output of the plant working continuously day and night, and the full power for the month of November, be taken at 100 units, whereas it is found that the actual output is 16·6 units, then it would be said that the load-factor was 16·6 per cent. In the summer months, at the same station, it may fall as low as 5 per cent. In order to compare the relative economy of fuel, water, or other material used in generating electrical energy, the author has fixed on a consumption of 25 lbs. of water and 2·5 lbs. of Welsh coal per unit generated as a standard which might be reached in the future, although nothing approaching those figures had yet been attained in practice. Mr. Crompton hoped to be able to make his paper perfectly general and impersonal, that is to say, to collect and tabulate data from a large number of supply stations, and from them to draw general conclusions as to the influence of the three items of load-factor, design and cost of material and labour, upon the cost of energy. Unfortunately, however, he did not obtain sufficient replies to his queries, and hence had to

confine himself mainly to the data drawn from the Kensington and Knightsbridge Electric Lighting Company and from the St. James's and Pall Mall Electric Lighting Company.

The load factor at these stations varied from the exceedingly low figure of 2·5 for the Kensington station in the month of August, to 41·5 on one occasion which represented the maximum load-factor of the St. James's station. At Kensington the load factor for the month of November is 12·1, for August 2·5, while for the whole year it is only 7·65. This is a residential district which gives a very unfavourable load diagram. The load factor of the St. James's and Pall Mall station for the month of December was 39·5, and for the whole year 24. This district contains most of the clubs, restaurants and theatres, and the requirements of private house lighting plays a secondary part.

Mr. Crompton showed how a low load factor affects the cost of labour as well as the cost of materials. The fact that in order to obtain a reasonable load on the steam dynamos it is necessary to sub-divide the work among a considerable number of engines, starting them one by one as the demand increases, adds to the number of attendants required at the station, and no saving on this point could be made if the energy were generated by means of one large steam dynamo worked through widely varying limits of load, as even then reserve plant of equal size would have to be provided and held in readiness in case of a breakdown. A great reduction in the cost of labour is effected by the use of storage cells to enable the current during 13 hours out of the 24 to be supplied from them instead of from the engines. At the Kensington station they are obliged to supply electrical energy continuously throughout the 24 hours, and if accumulators were not employed, the only alternative would be the use of special small and complete sets of moving plant, with reserve power of steam engines and dynamos. The use of a sufficient amount of storage cells to provide the energy during the thirteen hours of light load possesses many important advantages. In the first place the accumulators can be filled up at times of light load within the eleven hours that the engines are actually running. They can also be drawn upon to supplement the supply from the steam dynamos at the times of greatest demand, and so reduce the number of boilers and steam engines that require to be put into action for very short runs. In this way the shape of the load curve can be greatly improved. An additional advantage afforded by the use of accumulators is security against extinction of the light from a temporary stoppage of machinery. The author has gone very carefully into figures to show to what extent the storage cells increase the efficiency of the whole plant. Mr. Crompton plots curves representing the cost of materials used; engine-room labour; then the sum allowed for upkeep of engines and dynamos, which is taken at 6 per cent. for upkeep, and 5 per cent. for interest on plant. After this there is the sum on boilers taken at 10 per cent. and 5 per cent., and finally the upkeep and interest on accumulators, which is taken at 12 per cent. and 5 per cent. Throughout, 5 per cent. is added for interest on the capital expended. The mere addition of accumulators to meet one-tenth only of the output of the 24 hours is sufficient to reduce the cost of labour by 33 per cent., whereas the increase of cost due to the upkeep of the cells is small, so that the ultimate result is to lessen the total cost of production by 28 per cent. Referring to the loss of energy in accumulators, it has been found that at Kensington it never exceeded 20 per cent., thus the total loss due to the accumulators is only 4 per cent. of the whole; in other words the number of units generated has to be increased by 4 per cent. only.

Summarising the data obtained from the accounts of the Kensington Company and the St. James's and Pall Mall Company, it was shown that at Kensington, with a load-factor of 2·5 in August, the total cost per unit was 2·445 pence; in the month of December, with a load-factor of 21, it cost 1·081 pence. At St. James's and Pall Mall, with load-factors of 6·85 and 39·5 for the corresponding months, the cost of generating a unit was 3·092 pence and 1·414 pence respectively. These figures include coal, labour, and petty stores. The fuel used at Kensington has gradually fallen from 12 lbs. to 7·9 lbs. per unit generated, with a corresponding decrease in water and petty stores. A better load-factor, Mr. Crompton thinks, might possibly with the present machinery reduce this 7·9 lbs. to 4·5 lbs., and the labour cost may be reduced from ·442d. to ·2d. per unit. The author referred in high terms to the efficiency of Mr. Willans's engines, and the splendid examples of direct-driven steam dynamos at four large central stations at Berlin, and which were erected by the *Allgemeine Elektricitäts Gesellschaft*.

The cost of distributing energy has to be determined by that of the upkeep of the distributing plant and the percentage of energy which is lost by the fall of pressure in the conductors. It followed that the merit of competing systems was inversely as the cost of generating the units so wasted divided by the upkeep of the conductors. For instance, if in distributing 20,000 units to a given distance, system A wasted 1,000 units in a given time, the cost of upkeep for the same being £10, whereas system B wasted 3,000 units at a cost of upkeep of £3, then B was slightly better than A, in proportion of 300 to 333.

It is difficult to apply the method of comparison to the systems now in use, as the cost of upkeep is not yet known with sufficient accuracy. Mr. Crompton's opinion is that whenever underground mains consist of continuously insulated cables the sum required for upkeep would be not less than 4 per cent. of the original cost, and it is not likely to exceed 7 per cent. When, however, the underground mains took the form of bare copper conductors with glass or porcelain insulators, the cost of upkeep might be as low as from 1 to 2 per cent.

The author found difficulty in obtaining accurate accounts of the cost of distribution by the alternating transformer system, but all the published accounts had shown that the total net cost per unit was greatly in excess of that of the low-pressure system. He had under his charge a plant of generating and distributing machinery on the alternating transformer system for the public lighting of Chelmsford. In this case the machinery was worked for long periods at a high load-factor, so that the cost of generating was exceedingly low, and as the load in the transformers was perfectly regular, it had been possible to so proportion them as to be worked continuously at their maximum efficiency. The annual load-factor was found to be 31, and the consumption of coal 8·88 lbs. per unit generated, and 10·7 lbs. per unit delivered.

Mr. Crompton's paper offers much food for reflection, and

it will doubtless be quoted for some time to come; we hope that the discussion will bring forth the experiences of many who have hitherto been reluctant in supplying the kind of data of which we are so much in need at present.

The Phonopore.

WE observe in our contemporary, *Nature*, that Mr. Langdon Davies has recently published a small work which contains a plain explanation of his phonopore. We often hear of this apparatus, but it seems doomed never to pass beyond the experimental stage. Though it has now been some years before the public, we do not learn of any really successful practical application being made of it, probably because it is not really a practical instrument. We observe it stated that "five reports, written by well-known men . . . . . speak of this new system as highly valuable." We have not received a copy of the book, nor do we know who all the five writers of the report are; but we note that Professor Silvanus Thompson is one of the five, and that the Professor states—"In my opinion the experiments and demonstrations have been successful in establishing the entire practicability of satisfactorily working the simplex phonopore telegraph simultaneously with the ordinary telegraphs (both needles and Bright's bells) upon the same ordinary telegraph line." In *our* opinion such a report is not worth the paper it is written upon. Professor Thompson, though a most able man, has had no experience whatever of practical telegraphy, and is, therefore, utterly unable to speak with authority on the subject. Laboratory telegraphy is one thing, practical telegraphy is another, and those who have had practical experience of telegraph working know how widely the two differ, especially when apparatus has to be dealt with whose range of adjustment approaches to a knife edge. Ingenious the instruments undoubtedly are, but, we believe, not practical.

Ancient History.

WITH the acumen and perspicacity usual to the secular press in all scientific matters, the *Chicago Evening Post* gives the trite information that C. Bourseul described the electric telephone, and proceeds to state that Sir Charles Wheatstone invented his telephone in the year 1721. In regard to the latter statement, we must remark that when we last had the honour of conversing with that distinguished scientist, a month or two before his death, he seemed to bear the weight of his 175 years with remarkable lightness, and had sufficient energy left not only to attend to business but also to find time to write poetry and decipher love letters from the *Times*. Although the above astonishing account of the invention of the telephone was accepted, we hear that the following note was rejected. "Notwithstanding the immense credit due to Wheatstone and C. Bourseul for their pioneering steps in the development of the modern telephone, there can be no doubt that Dame Nature was the producer of the first successful attempt at conveying sound to a distance. This apparatus does not reproduce human speech, but in other respects it far outstrips the machine now in use, for no wires are requisite, nor is an electric battery necessary for its satisfactory working. Nature completed its work at a period of the earth's existence when the waters covered the earth, and nought was heard save the soughing of the wind and the lapping and rushing of the waters tossed to and fro on the mighty ocean. These being the only kinds of sound extant when the instrument was evolved, they are the sole kind capable of being transmitted; yet so perfect is the mechanism, that on placing the instrument to one's ear the moaning and breaking of the waves can be distinctly heard even when the listener is hundreds of miles from the seashore. Constructed of pearl, there is much controversy as to which shell was used for the first instrument made, and the eminent professors Rem Nants, of Palæozoicage, C. Hunks, of Old Red Sandstone, and N. O. Dules, of Blue Lias, had quite a heated argument as to the relative merits of the claim to that honour advanced on behalf of *Cochliodus contortus*, *Goniatites crenistria*, and *Ammonites Margaritatus* respectively, but eventually, as a compromise, it was decided that the cowry had the best claim." "Our readers will be surprised to hear, also, that the 'Pinaphore' or apparatus for conveying the representation of a scene to a distance, was first described in the veracious history of the Peri Banou." In spite of the self-evident appearance of truth about the above note, it was rejected for that very reason. Scientific paragraphs should always be couched in mysterious language in order to add to the mystification of all outside the particular clique.

Primary Batteries.

IT seems evident from the criticisms which have been passed upon the De Meritens battery when the matter was under discussion before the International Society of Electricians, in Paris, that the invention may be put in the same category as the erstwhile famous "auto-accumulator" of M. Paul Jablochkoff. It is not likely that anyone who has the pleasure of M. Hospitalier's acquaintance would be led away by the idea that he introduces personal matters into his experimental researches, and we have not the slightest doubt that when the other independent tests on the battery have been completed, M. Hospitalier's results will be entirely confirmed.

A New Form of Megohm Resistance.

WE notice in the Franklin Institute Journal for this month a paper with the above heading. At first sight it appeared that the author supposed that a high resistance made by a lead pencil mark upon a block of ebonite or a glass plate was an entirely novel idea, but luckily he qualifies his "new form" as follows:—"The instrument of which the paper treats is not new entirely, but has been used for some years in England to a limited extent, so that the title refers mainly to its introduction in this country." The late Robert Sabine constructed several approximately correct megohms in the above manner, nearly 20 years ago, for testing the West Indian Cables.

Statistics of the American Telephone Industry.

THE annual report of the American Bell Telephone Company, which is summarised in the last issue of the New York *Electrical Engineer*, shows a large and steady growth in the industry. The earnings during 1890 reached the substantial figure of $4,375,290, as compared with a little over $4,000,000 in 1889. Out of this sum, not less than $2,213,913 was paid out in regular and extra dividends, representing the earning and profit yielding capacity of the capital stock of $12,500,000; while the large amount of $600,000 was carried to reserve for general depreciation, and an additional $55,500 for depreciation on instruments. The other data contained in the report shows 483,790 instruments under rental, a gain of nearly 40,000 over 1889, while the number of connections reached 450,000,000, or about 3 per day per subscriber. The company through its Long Distance sub-organisation has been able to make remarkable progress in connecting together the various telephonic centres and systems; and its highly intelligent and creditable work in this new department is already bearing good fruit, not only in securing dividends on the investment, but in giving increased facilities of communication to the public. Such a report as that above referred to, says our contemporary, is likely to add to the unusual interest now attaching to the telephone situation, and its imposing totals of earnings and profits will make many mouths water. It is needless to point out that in a year or two this great system, built up with so much care and effort and ability, may be subjected to considerable strain. The figures indicate, however, a strength of organisation and powers of endurance that bid defiance to assault, even if there were not left a single patent as a bulwark of protection.

ALTERNATING CURRENTS OF HIGH FREQUENCY.* A REPLY TO MR. TESLA.

By ELIHU THOMSON.

In regard to the comments of Mr. Tesla published in the *Electrical Engineer* of March 18th, concerning my note in your issue of the 11th, I think it desirable that I should make a few remarks. Mr. Tesla appears to infer that my investigations of the properties of alternating currents of high periods must have been subsequent to the note which was published in the *Electrician* a few months ago stating that I had constructed a high period machine. I would say that as soon as that machine was completed I made quite a number of investigations in relation to the properties of these currents, but did not have time to put them in shape for publication.

In regard to the experiments with the incandescent lamp bulb and the strip of filament mounted on a single wire, I cannot agree with Mr. Tesla at all that conduction through the glass has anything to do with the phenomenon it presents. It is well known that an incandescent lamp bulb if held in the hand is capable of acting as a Leyden jar and will receive and retain a charge from a static machine of very high potential, and that a very violent Leyden jar shock, with a long spark, may be obtained by bringing the free hand towards the neck while holding the bulb after charging, as mentioned. If conduction through the glass were a possibility this action could not occur.

Mr. Tesla thinks that I have misunderstood his statement about the limit of audition. From my point of view I think that he has misunderstood my statement about it. He had stated that he had experimented with 10,000 to 20,000 alternations per second. I pointed out that this would correspond to 5,000 to 10,000 complete waves of sound, and equally, I may now say, complete waves of current. The limit he had adopted, or suggested, was about 10,000 waves a second. It is evident that his experimenting with from 5,000 to 10,000 complete waves would be working below this limit of audition, even taking the low value which he had suggested for it. I have heard sounds of 20,000 complete waves per second. The physical cabinet of the Central High School, at Philadelphia, contained, at the time of my connection with the Institution, apparatus which enabled a test of one's hearing powers in this respect to be easily made.

I agree with Mr. Tesla that the success of an arc light system depends upon good management; and I include in the term good management, good design, good construction, good supervision, and good commercial work, which includes the ability to stand considerable bad management in the running.

Five or six years ago it occurred to me to try the construction of a dynamo for constant current in which the armature coils were of a highly efficient type, that is, of comparatively short wire length for the voltage and moving in a dense magnetic field. Exteriorly to the coils, and to the field, I had placed (in the circuit of each coil) an impedance coil, which consisted of an iron core wound with a considerable length of wire and connected directly in circuit with the armature coil. I thus obtained, as I thought, the property of considerable self-induction along with efficient current generation, and by separate devices, I expected that possibly the effects would be very much the same as those obtainable from the regularly constructed arc apparatus. In this I was disappointed. The effect was to shift the diameter of commutation forward and to lower the capacity of the machine, while the properties otherwise were not so greatly changed. The requirement in the arc machine is simply that there shall be a droop or dip in the characteristic curve at about the point of normal current, and at a rate dependent upon the character of the lamps used with the machine. Differential lamps require for stability less droop or dip than lamps feeding entirely by the shunt or derived circuit. Without doubt, arc machines give better effects when the field magnets are in series, not only on account of the resistance of such magnets, but also because of their self-induction tending to smooth out and obliterate vibrations or undulations of current which would otherwise have a direct passage from the commutator brushes to the circuit.

Mr. Tesla has evidently misunderstood my meaning when I spoke of the introduction of a coil of large self-induction in series with arc lamps as not affecting their feeding. I had no reference to any instability of current "involving large variations, and occurring at large time intervals," in this case, as the machinery I used was of a stable character and did not give rise to the instability at which he here seems to hint. I meant that a coil of large self-induction cut down, or wiped out vibrations or undulations of current and reduced them to a very slight amount, *i.e.*, prevented them from existing in the circuit, just as such coils will wipe out the waves of speech in a telephone circuit, only the effect here is, of course, on a larger scale.

In relation to the feeding of a lamp which operates by a clutch, I do not deny that a slight vibration of the parts will, or may, benefit the feed, but I think the same slight vibration will benefit the feed of the clock-work lamp also. On this point Mr. Tesla contented himself by simply saying that he cannot agree with me, and that he thinks these vibrations do not at all benefit a clock-work lamp. I disagree with him there, because I think they *must*, as the vibration tends to keep all the moving parts free to act and avoid the sluggish effect of starting friction. In the clutch arc lamps of the Thomson-Houston Electric Company for many years past, the clutch has been attached only to the feeding regulating lever by an elastic spring, and the result of this spring suspension or elastic connection (the properties of which I discovered as far back as 1879 or 1880) was that the feeding action by clutches was greatly improved; not, however, because the spring served to damp vibrations, though it undoubtedly did so act, but because it secured an action of the clutch which was equivalent to an automatic slip instead of a free release. In this connection I may mention that I have built and used very many forms of arc lamps of both the clutch and the clock-work types.

I have frequently operated clock-work lamps of Mr. Wood's construction on Thomson-Houston arc machines, and clutch lamps on machines of the Gramme type, and have, moreover, frequently run mixed circuits of lamps with several types of lamps in the same circuit on either type of machine indiscriminately. The lamps, so far as could be determined by an inspection of the arcs, worked very satisfactorily and in no way different from their normal behaviour. I doubt not that there are arc plants in operation in which machines of different makes and types are interchanged, and in which lamps of different makes and different types are found mixed on the same circuit, and while this may not be very desirable always, still there is no reason why the results obtained should not be satisfactory, if the types of apparatus are good, well made and properly taken care of.

While I think it possible that the smaller physiological effect of high period alternating currents may be due to some difference in distribution, still the experiments of Dr. Tatum do not give any indication of such a result, though he sought for it. I cannot say that his experiments were perfectly conclusive on this point. From the fact, however, that the sensory nerves are to be found on the exterior of the animal body in the greatest abundance, and adapted to receive outside impressions, it would seem that the experiments of Dr. Tatum, which show that a greater amount of current at a high period could be tolerated voluntarily, are at least indicative of the fact that the current did not traverse the cuticle where the nerves are so sensitive. In such a comparatively poor conductive material as animal tissue, it appears to me very probable that the distribution of current will be determined largely by conductivity of the layers, and not by self-induction to any great extent, especially as the amount or density of the current which may in any case be supported is so very small.

I confess that my statement as to the motive of my critical remarks may have been out of place. They were elicited, however, by Mr. Tesla having on a former occasion misunderstood my motives and having acted on that misunderstanding.

* See ELECTRICAL REVIEW, for April 3rd, 1891.

By CHAS. STEINMETZ.*

I read, with great interest, Mr. Tesla's and Prof. E. Thomson's account of their experiments with alternating

* New York *Electrical Review*.

currents of very high frequency; the greater, as my experience with high speed alternating machinery enabled me to fully appreciate the enormous difficulties connected with the mechanical production of such enormous frequencies.

Indeed, in my experiments, I never went by far so high as they did, and I am not musician enough to judge whether such a machine would be fit to accompany a thoroughly Wagnerian opera, as Mr. Tesla thinks; but, at least, I doubt it, because the one machine—of a design somewhat similar to his—which I once built, gave out a howling resembling much more an Indian war whoop, only a little more frightening, than anything else. And it was a very remarkable machine, too; the boys in the shop called it the "humming bird," and it goes now by this name. Perhaps I shall refer at a later occasion to the interesting experiments made with this machine, which, among other features, gave continuous magnetisation from alternating currents without commutation.

It seems, indeed, that the advantages of reaching such high frequencies, not by static discharges, but with machines powerful enough to yield perceptible *currents* of electricity, amply compensate for all the difficulties encountered therewith. Because these experiments made with frequencies of 20,000 to 30,000 per second form the connecting link between the phenomena of the alternate currents used in practical engineering, and those electric disturbances of millions or hundreds of millions of vibrations per second, which give rise to the Hertzian ether waves of radiating electricity.

And this fact explains all the experiments shown by Mr. Tesla and Prof. Thomson. Most of them, indeed, show truly static effects of oscillating electric disturbances, like the oscillating discharge of the induction coil in Hertz's experiments, only that in this case where the electric disturbances are backed by *currents*, which count by horse-powers, much more brilliant effects appear.

Is is certainly not *conduction* through the air which makes an incandescent lamp, entirely disconnected from the machine, light up, but it is the action of the radiating energy of the electric ether waves. Not the secondary current of the induction coil is felt by the hand which holds the incandescent lamp, but the electric charge influenced in the hand as the outer condenser coating, just as we draw sparks from the outer coating of a Leyden jar when the inner coating is charged by a static-electric machine, and feel every spark which jumps over from the machine conductor to the inner coating.

Various forms of the screening effect of metals, with regard to those waves, are shown by Mr. Tesla. Reflection and refraction, indeed, he could hardly expect to observe, because, even with 30,000 alternations per second, the wave length of the electric disturbance in space amounts still to something like seven miles.

But the whole space surrounding such a machine has to be considered as an electro-magnetic field of force, and a very powerful one, too, because of the enormous strain exerted upon the dielectric by the high pressure of the induction coil.

It is only to be regretted that in all the reports of Mr. Tesla's experiments nowhere anything is stated about the E.M.F. of those electric secondary currents. This omission rather impairs the value of these experiments somewhat. The E.M.F. of the primary current Mr. Tesla gives as 500 volts. But how did he measure the alternating pressure of 30,000 vibrations per second; by static electrometer? Because any dynamometer would be unreliable under these circumstances.

I think, although any closed circuit voltmeter would be entirely out of question for such high frequencies, a modified electro-meter, built for very low capacity, would, perhaps, answer the purpose of measuring the secondary E.M.F., and could be built so that it could be used for determining the E.M.F. and also the electric energy, that is, the power consumed by the circuit. This seems to me of very great importance, because it would give the means to determine by experiment the amount of electric energy which radiates into space as electric ether waves, that is, the time hysteresis of air.

I should suggest to determine the whole energy of the electric current by an electrostatic wattmeter, and the energy converted into heat in the conductor by a calorimeter. The difference would give the energy of radiation. Indeed, enormous practical difficulties would have to be overcome to carry out this scheme.

The condenser, such an inefficient and cumbersome apparatus for circuits with the usual number of periods, becomes very powerful and compendious for such high frequencies as 30,000 per second, and systems of electric distribution by means of condensers would be very well conceivable, if much higher frequencies than now could be used in practical engineering. Already some years ago such a system of distribution by condensers, with a frequency of, I believe, 800 per second, was proposed by a European electrician, but never tried, I suppose. (Account of it is to be found somewhere in the "Centralblatt für Electrotechnik," Munich, Germany.)

However, I believe that for electric light and power distribution such frequencies as Mr. Tesla used are quite out of question, and I am much more inclined to think that even the frequencies now in vogue in this country, of in maximo 138 complete periods per second (Westinghouse), or 16,000 alternations per *minute*, will not be kept much longer, but will be reduced as soon as possible. They are now used only because of the small unit of converters found in this country, which for efficient work need a high frequency.

But I entirely agree with Mr. Stanley that it is most desirable for efficient work to proceed to larger converter units, and that then a reduction of the number of alternations will be made. In the old country, where the practice is to use the converter as a kind of secondary station and to feed a whole district from one converter or a bunch of converters, the converter unit is much larger generally, and therefore a much lower frequency, only 42 complete periods per second, permissible. This reduces the loss by hysteresis very greatly, and this loss is known as the most important factor, because of being about the same for no load as for full load, and especially determines the all-day efficiency.

Indeed, even in this country, for arc lighting by means of alternating currents and series converters, the number of alternations has been reduced already to one-half, 8,000 reversals per minute, in the Stanley-Westinghouse constant current alternator, I think, because it was very difficult to work any electro-magnetic regulating mechanism with the frequencies of incandescent light currents.

It is not the question whether magnetism can be produced at all by very rapidly varying currents, but the question of *self-induction*, that is, whether a current strong enough to work the regulating mechanism can be forced through its energising coil against the counter E.M.F. of self-induction, without consuming too much pressure, which limits the number of vibrations permissible in electro-magnets and motors.

I will not try to decide which is the highest number of periods permissible for effective working of alternating motors, and whether this limit is higher than the number of periods practically used; but it must be borne in mind that until now no alternate current motor is on the market which runs with halfway fair efficiency with the number of alternations used for incandescent light circuits, 16,000 per minute, while in Europe, where a much lower number of alternations, only 5,000 per minute (Ganz & Co.) is used, alternate current motors are already on the market and in practical use and reach a very fair efficiency. And, nevertheless, in the use of electricity as motive power, the United States are undoubtedly a long way ahead of other countries.

As before said, it is not the impossibility of producing magnetism by rapidly varying currents which makes them unfit to run motors, but the enormous self-induction, which necessitates the waste of an enormous pressure to send even a small current through the inductive resistance.

For magnetism is produced with still much more rapidly oscillating currents than those which Mr. Tesla had at his disposition, as the fact proves that magnetisation, and even permanent magnetisation of steel rods, has been produced by oscillating condenser discharges and lighting strokes. Steel rods were found permanently magnetised at such occasions, and the curious phenomena was, that by grinding off the surface of the steel rod, the magnetism decreased—reached zero, reversed its polarity—increased by further grinding off to a maximum in the opposite direction as that of the magnetism of the integer rod, and then decreased again and even reversed its polarity once more.

The explanation for this phenomenon is that the discharge was oscillating, with increasing wave length but decreasing intensity. The first wave magnetised only the very surface of the steel rod strongly, but because of its very short duration and the screening effect of the metal, did not enter

deeper into it. The second wave, of opposite direction, was not strong enough to reverse the magnetism produced by the first wave, and only weakened it somewhat; but because of its longer duration it entered deeper into the steel and magnetised the layer underneath in the opposite direction to the surface, so that by grinding off the surface layer the magnetic moment of the rod reversed; and if the resistance of the electric circuit was low enough to allow a third wave to be produced with perceptible intensity, underneath the second layer a third one was found, magnetised in the same direction as the surface. This phenomenon shows that even such very rapid oscillations produce magnetism.

I was very much interested in reading the arguments which Prof. Thomson proffered for the existence of carbon vapour in the electric arc, and I must consider the arguments as very strong. The only fact which seems to me not quite in agreement with the existence of carbon vapour, is the spectrum of the electric arc. The copper arc, the iron arc, show the characteristic spectra of those metals, with their many lines. The carbon arc, if containing carbon vapour, ought to show the—until now unknown—carbon spectrum. But nothing of that kind; it gives an entirely continuous spectrum, quite similar to the spectrum of glowing solids.

This fact, I believe, needs still a satisfactory explanation, and I should like to hear how Prof. Thomson explains the absence of a characteristic carbon spectrum in the electric arc.

I should like to hear, also, whether any experiments have been made to determine the exact temperature of the arc and the glowing carbons. The only temperature determinations of which I know are already of rather old date and made by an Italian, Rosetti, which measured the heat radiation by means of a thermopile and found the temperature of the tip of the positive carbon to 3,900° C., the tip of the negative carbon to 3,150° C., but the temperature of the flame higher —4,800 to 4,844° C. These figures do not agree with the data given by Prof. Thomson, who considers the positive carbon as the hottest part of the circuit. Rosetti used currents from 3 to 6 ampères.

The explanation of the instability of the electric alternating arc, because of the alternating cooling off of the carbons during the zero period of the current is certainly the nearest one, and, therefore, generally accepted. But whether it agrees with the real proceedings must still be doubted. Theoretically, at least, these fluctuations of temperature should be expected to be so small that they could have no influence on the conductivity of the arc.

An experiment to determine the fluctuations of temperature of an electric conductor, caused by the alternations of the current, was made on a piece of copper wire, one millimetre thick and 657 centimetres long. A current of 6·4 ampères was sent through with only 5,840 alternations per minute, and the lengthening of the wire measured. The increase of temperature was 37° C.; but the maximum variation of temperature calculated to only ·019 degree C., that is, one-twentieth per cent. of the whole rise of temperature. ("Das Gesetz zwischen Ausdehnung und Stromstärke für einen von galvanischen Wechselströmen durchflassenen Leiter," von Dr. Cranz, Zeitschrift für Mathematik und Physik, Dresden, 1889, p. 92.) Although this calculation is not quite conclusive for the somewhat different conditions in the electric arc, it is sufficient for making the assumption of so great and rapid cooling down of the arc during the time zero current doubtful.

But if we consider the energy consumption of the arc as caused by a counter E.M.F., a kind of polarisation, and at the hand of the facts must assume that this counter E.M.F. of the arc in very wide limits is nearly independent of the current strength, then the apparent resistance of the arc must vary inversely as the current intensity, and in consequence of this, in an ordinary alternating arc light circuit, the height of the current wave must be increased at its crest, decreased near its minimum position, so that the time of minimum current is greatly increased, and the shade of the wave becomes more triangular.

But if the alternator is so well self-regulating that the current wave, in spite of the varying resistance, is kept sinusoidal, that is, regulating in time so short that it is small even in comparison with the wave length of the alternating current, as is the case in the Stanley-Westinghouse constant current alternator, then the alternating arc should become just as steady as the continuous current arc. Now, in Mr. Tesla's high frequency machine this condition was certainly fulfilled, its self-induction being very large, as the tendency of yielding constant current shows, and self-induction regulated the impressed E.M.F., according to the sine wave of the current producing the rectangular shape of the wave of impressed E.M.F., as shown in the curves given by Messrs. Tobey and Walbridge, for the Stanley-Westinghouse alternator, in their paper read before the American Institute of Electrical Engineers.

This particular shape of E.M.F. and current might have a great deal to do with the steadiness and unsteadiness of the arc.

Therefore, it would be of very great interest, in the same way as it has been done in Cornell University with the Stanley-Westinghouse alternator, to determine the shape of the E.M.F. and the current wave for an alternator of very low self-induction, for instance, with a disc armature, running arc light. Then I should expect to find the opposite phenomenon; the impressed E.M.F. retaining its sinusoidal form, and the current wave assuming a more triangular, shape, at the same time causing unsteadiness of the arc.

Yonkers, N.Y., *March 26th*, 1891.

THE EQUILIBRIUM OF DIELECTRIC FLUIDS IN AN ELECTRIC FIELD.

According to the theory of von Helmholtz (vide *Wiedemann's Annalen*, vol. xiii.) when a dielectric fluid is placed in an electric field it is necessary in using the equations of hydrostatics to introduce complementary terms in order to take account of the action of the field. H. Poincaré has recently been investigating the subject, and on March 16th he read a paper before the Paris Academy of Science.

Let us suppose that the exterior forces other than those due to the action of the field, are reduced to that of weight, then the equation of Helmholtz may be written

$$d p + \frac{g\, d z}{v} + \frac{F^2}{8\pi} d K + d\left(\frac{v}{8\pi}\frac{d K}{d v} F^2\right) = 0$$

in which it is only necessary to notice that

p = the pressure of the fluid.
v = the specific volume of the fluid.
K = the specific inductive power of the fluid.
F = the intensity of the field.

From this equation it follows that

$$\frac{F^2}{8\pi} d K - g z d\left(\frac{1}{v}\right)$$

should be an exact differential. This differential should be considered as *nil* in the interior of a similar fluid when the temperature is constant.

Practically speaking, a liquid is incompressible, consequently the $\frac{1}{v}$ and the K are constants, for K only depends upon v.

If we are dealing with a gas $\frac{1}{v}$ may be regarded as practically *nil*, and K being approximately equal to the specific inductive power of a vacuum may be considered constant.

But if there are several fluids which differ amongst themselves chemically, the differential will be in this case very great in the layer which separates them. This enables us to write the equation of the surface of separation of any two dielectric fluids whatever.

Let v_1 and v_2 be the specific volumes of two fluids, and K_1, K_2 their specific inductive powers.

The intensity of the field, F, is not continuous and undergoes a sharp "throw" when the surface of separation of the dielectric fluid is passed. Let N_1 be the normal component and T_1 the tangential component of this force in the neighbourhood of the surface of separation and *in* the first fluid. Let N_2 and T_2 be the same components respectively in the

neighbourhood of the surface of separation and *in* the second fluid. Then, according to the classical theory of dielectrics, we have

$$T_1 = T_2 \text{ and } K_1 N_1 = K_2 N_2$$

and the equation of the surface of separation will become

$$\frac{T_1^2}{8\pi}(K_1 - K_2) + \frac{K_1^2 N_1^2}{8\pi}\left(\frac{1}{K_2} - \frac{1}{K_1}\right) - gz\left(\frac{1}{v_1} - \frac{1}{v_2}\right) = \text{const.}$$

It would be curious to compare this form of the equation of Helmholtz with certain experiments of Quincke, which could be able, without doubt, to be explained thus, without interposing, as various persons have endeavoured to do, those tensions which, according to Maxwell, predominate in the direction of the lines of force, and those pressures which exist perpendicularly to the direction of these lines: these experiments might then be regarded as a *demonstration of the real existence* of these tensions and pressures.

But this theory is probably incomplete, for it is possible that there exists at the surface of separation of two dielectrics a difference of potential which it is necessary to take into consideration.

THE SUPERPOSITION OF LONGITUDINAL AND TRANSVERSE MAGNETISATIONS.

IT has been demonstrated experimentally by Jamin that two longitudinal magnetisations of inverse polarity may be superposed, as it were, upon the same plate of steel, and that they neutralise without destroying each other; whilst H. C. Decharme has shown that the same thing occurs in the case of two transverse magnetisations of contrary polarity (*vide Comptes Rendus*, August 18th, 1890). At a meeting of the Paris Academy of Science, on March 9th, Decharme described some further experiments upon the superposition of longitudinal and transverse magnetisations. These conditions were successively communicated to the same plate of steel, and it was found that in this case neutralisation, properly so-called did not take place, the acting forces being no longer directly opposed, but perpendicular one to the other.

After having magnetised a plate of steel, 100 mm. long by 28 mm. broad and 3 mm. in thickness, and then magnetised it transversally by one of the methods indicated in the previous communication, Decharme found that the effects of both these magnetisations were shown simultaneously to a more or less perfect degree, or else that the longitudinal magnetisation disappeared and gave place to the transverse magnetisation which was produced last. By practising a few more longitudinal passes the transverse magnetisation can in this case be caused to disappear and to give place to the phenomenon of longitudinal magnetisation.

Either condition can be replaced by the other by slightly modifying the conditions of the experiment. When, however, these alternate transverse and longitudinal conditions of magnetisation are continued for some time, the magnetic "layers" increase more and more, and the steel tends towards saturation. As this point is approached it begins to be sufficient to make fewer and fewer passes in order to cause one or the other of these conditions to predominate. In fact a sort of unstable equilibrium is reached in which the smallest addition of force will cause a disturbance. The extreme to which this may be pushed may be called the *critical point*.

Decharme considers that circular and helicoidal magnetisations can be conceived possible and might be obtained by suitably combining the action and direction of the magnetic forces.

THE ELECTRIC LIGHTING OF AMSTERDAM.

[FROM OUR OWN CORRESPONDENT.]

AMSTERDAM has resolved on the introduction of electric light, which is to be successively enlarged, so as to supply the entire city. For this purpose a concession has been granted to the local company "Electra," and operations for the erection of suitable works have been already commenced.

This electric establishment is opposite the existing gas works, and its distance from the centre of the district to be lighted up is about 3½ kilometres.

On account of this distance the system of conduction with alternating current transformers comes into use.

As the first step towards the electric lighting, there is proposed a capacity of 20,000 glow lamps at 16 normal candles, and the works will come into action to this extent in the next winter.

The "Helios" Joint Stock Company for the construction of electric light installations and telegraphs, of Cologne-Ehrenfeld, has been entrusted with the supply and construction of the entire installation. This company is the German licensee of Ganz & Co., of Budapest, and will use the distribution system of this firm at Amsterdam.

For generating the current there will be set up three alternating current machines of the Zipernowsky type A_8, each of 320,000 watts, and a machine, A_7, of the capacity of 160,000 watts with their accompanying exciters. The A_8 machines will be driven by steam engines, each of 600 H.P., and for the A_7 machines one of 300 H.P., which will be directly connected with the dynamos.

These machines with the boilers, and all accompanying plant, transformers and cable leads, form that portion of the installation which is to be completed and brought into play this year. But orders for an extension of the works have been already given, to be completed in the course of the following year.

THE DEVELOPMENT OF ELECTROMOTIVE FORCE BETWEEN MERCURY AND AN ELECTROLYTE.

FOR the full development of the electromotive force between a metal and an electrolytic solution a certain amount of time is required, for in order to effect the charging of the metallic surface a movement of the ions is necessary, and this can only take place at a finite rate.

By the use of dropping electrodes, F. Paschen has recently succeeded in measuring the electromotive force between mercury and aqueous solutions of sulphuric acid, hydrochloric acid, cupric sulphate, and zinc sulphate, when the mercury is flowing at different rates.

The speed of outflow may be so small that single drops are formed at the end of the capillary and fall separately through the liquid, or the rate may be so fast as to give a continuous jet of mercury for some distance from the mouth of the tube. By measuring the length of this mercury jet from the capillary to the point when it begins to break up into drops, and then dividing this value by the speed of outflow, the time can be calculated during which a surface particle of mercury is in electrical contact with the electrolyte and the electrometer simultaneously.

The results obtained by Paschen in this series of experiments demonstrate that the mean difference of potential at a mercury surface, which is increasing in size in an electrolyte, does not depend so much upon the nature of the increase as on the time during which each surface particle is in contact with the electrolytic solution.

We may conceive the phenomenon which is produced as a charging of the surface, and the mean electromotive force at this surface is made up of the electromotive forces of the separate particles during the time of their contact with the electrolyte.

The beginning of the "charging curve" is to be sought at times less than $\frac{1}{10^5}$ seconds. The charging goes on rapidly up to $\frac{1}{10^3}$ seconds, after which the electromotive force increases much more slowly, the increase being very little for hydrochloric acid, but considerable in the case of sulphuric acid, and when sulphates of zinc or copper are employed. This last increase is probably due to the formation of a mercury salt on the surface. The above is a condensation of a paper which recently appeared in two parts in the *Ann. Phys. Chem.*, xli., pp. 801—832, and pp. 899, 900, to which we must refer those of our readers who wish to study the investigation in detail.

THE ELECTROLYTIC METHOD APPLIED TO RHODIUM.*

By EDGAR F. SMITH.

So far as I have been able to learn, the salts of rhodium have never been subjected to the action of the electric current. I, therefore, made experiments in this direction and obtained results indicating the possibility of employing the electrolytic method in the estimation of this metal. The various texts consulted led me to believe that in all likelihood a solution of the double cyanide of rhodium and an alkali metal would best answer my purposes. Precipitation did not occur upon mixing solutions of potassium cyanide and rhodio-sodium chloride. The liquid remained clear. As soon, however, as a comparatively feeble current acted upon the double cyanide, a reddish yellow coloured compound appeared, and remained suspended in the liquid. It was probably a cyanide which sustained no change. I did not attempt a repetition of this experiment.

From my experience in the electrolysis of gold, platinum and palladium solutions containing alkaline phosphates and free phosphoric acid, I concluded to try rhodium under similar conditions. Sodium rhodium chloride, $Na_6Rh_2Cl_6 + 24H_2O$, was the salt used by me. A sufficient quantity of it was dissolved so that 10 cc. of liquid contained, by calculation, 0·0980 gram of metallic rhodium.

Experiments.—(1) To 10 cc. of the rhodium solution were added 30 cc. of sodium phosphate, Na_2HPO_4 (sp. gr. 1·0358), and 3 cc. of phosphoric acid (sp. gr. 1·347). The total dilution of the electrolyte was 180 cc. The current gave 1·8 cc OH gas per minute. In seven hours the deposition of metal was finished.

Weight of crucible + rhodium = 63·4765
" " " alone, = 63·3783

Rhodium = 0·0982

The deposition of metal occurred at the ordinary temperature. At the beginning of the decomposition the liquid showed a beautiful deep purple colour, but as the metal separated, it rapidly became lighter and finally colourless. Upon inclining the dish in which the precipitation was made, thus exposing a fresh metal surface, the latter remained perfectly clear. The precipitation of metal was completed.

(2) The conditions here were nearly the same as in the preceding trial. The total dilution of liquid equalled 200 cc. while the current gave 1·6 cc. of OH gas per minute.

The metallic rhodium was precipitated upon copper-plated platinum dishes. It was rather black in color, very compact and perfectly adherent. It was washed without any difficulty. Hot water was used for this purpose. The drying was done upon a warm iron plate.

The results obtained accord so well with the theory that the accuracy of the method cannot be questioned. The rapidity with which the metal is deposited, and the ease with which it may be handled also recommend this method of estimation.

Chemical Laboratory of the Univ. of Pa.,
Philadelphia, *February 13th*, 1891.

THE ELECTROLYTIC DETERMINATION OF MERCURY.*

By EDGAR F. SMITH.

In gravimetric analysis mercury is frequently obtained as sulphide. To weigh it as such, or to convert it into some form suitable for weighing, requires much time and close attention to insure results that will be at all satisfactory. It is, therefore, better to have recourse to the electrolytic method of determination. As mercury sulphide dissolves quite readily in the fixed alkaline sulphides, I electrolysed such solutions. The results show that this procedure affords a very accurate and clean method for the estimation of this metal.

* Read at the Franklin Institute Chemical Section's meeting, February 17th, 1891.

The sodium sulphide was prepared as described in the paper relating to the determination of gold. Its specific gravity was 1·19.

Solutions of mercuric chloride, containing a known amount of metal were first tried. The table shows the conditions of experiment and the results:

Mercury present in grams.	Sodium sulphide present. Sp. gr. 1·19.	Total dilution.	Current in cc. OH gas per minute.	Mercury found.
0·1903	20 cc.	125 cc.	1 cc.	0·1902
0·1903	20 cc.	125 cc.	1 cc.	0·1905
0·1903	20 cc.	125 cc.	1 cc.	0·1907
0·1903	20 cc.	130 cc.	1·2 cc.	0·1910
0·1903	30 cc.	130 cc.	1·2 cc.	0·1900

The precipitation extended through the night. The deposited mercury was gray in colour and very compact. Only once was a tendency to the fluid form observed. Hot water was used for washing. The metal was dried by holding the platinum dish in the palm of the hand and blowing gently upon the deposit.

If mercury and arsenic are both present in a solution of sodium sulphide, the current will throw out the former. It will not carry down any arsenic. This is evident from the two analyses that follow:

Mercury present.	Arsenic present.	Sodium sulphide.	Total dilution.	Current in cc. OH gas per minute.	Mercury found.
0·1903 gr.	100 p.c.	25 cc.	125 cc.	2 cc.	0·1908 gr.
0·1903 gr.	100 p.c.	25 cc.	125 cc.	2 cc.	0·1894 gr.

In the communication upon the deposition of gold from sodium sulphide solutions, mention is made that gold and tin could not be separated electrolytically when present together in a solution of that kind. I was, therefore, rather surprised to discover that mercury could be separated from tin under such circumstances. The conditions of experiments were similar to the following:—

The solution contained 0·1903 gram of mercury, 0·1200 gram of tin, and 30 cc. of sodium sulphide. The total dilution was 125 cc. The current gave 2 cc. of OH gas per minute, and acted for twelve hours. The precipitated mercury weighed 0·1909 gram.

The filtrates from the mercury deposits did not show even traces of this metal when they were examined.

Chemical Laboratory of the Univ. of Pa.,
Philadelphia, *February 13th*, 1891.

THE ELECTROLYTIC DETERMINATION OF GOLD.*

By EDGAR F. SMITH.

Gold has been estimated electrolytically in solutions, containing it as a double cyanide, or in the presence of sodium phosphate and phosphoric acid. From recent experiments I am satisfied it can be determined in the same manner by the decomposition of solutions of sodium sulphaurate.

Years ago Parodi and Mascazzini (*Zeit. f. Analyt. Chemie*, 18, 588), showed that antimony was completely precipitated from solutions of its ammonium sulpho-salt by the electric current. Classen elaborated this idea (*Ber.* 14, 1,622; 17, 2,467; 17, 2,245; 18, 1,110), substituting sodium sulphide for ammonium sulphide, and succeeded in effecting a most excellent separation of antimony from both tin and arsenic.

The sodium sulphide, used in the experiments recorded in this communication, was prepared by supersaturating a definite volume of caustic soda (1·3 sp. gr.) with hydrogen sulphide gas. An equal amount of caustic soda was then added, and the current of hydrogen sulphide continued for

* Read at the Franklin Institute Chemical Section's meeting February 17th, 1891.

some hours through the solution. The liquid was then rapidly concentrated, until a crystalline scum appeared upon its surface. In this condition it was placed in bottles provided with tight-fitting corks. Crystals separated as the liquid cooled. These were recrystallised, and then dissolved for use. The specific gravity of their solution equalled 1·1800.

Experiments.—(1) To a chloride solution of gold containing 0·1446 gram of metallic gold, were added 10 cc. of sodium sulphide (Na_2S), and 100 cc. of water. The electric current, allowed to act upon this mixture, gave 2·6 cc. OH gas per minute. The time of precipitation extended through the night.

The deposit of metallic gold weighed 0·1446 gram. It was bright yellow in colour, and very adherent. Water alone was used to wash it. The drying was done upon a warm iron plate.

(2) In this experiment the same quantity of gold was present as in the first trial. The volume of sodium sulphide did not exceed 20 cc., while the total dilution of the electrolyte was 100 cc. The current gave 2·6 cc. OH gas per minute. The metallic deposit was bright in appearance, firm and adherent. It weighed 0·1446 gram. The precipitation was complete in five and one-half hours.

The depositions of metal were made directly upon platinum. The gold was removed by covering it with a dilute solution of potassium cyanide, allowing the latter to remain for several hours in the dishes. When desired, the gold deposit can be very speedily removed by connecting the dish with the anode of a battery, and employing a platinum rod, which dips into the solution, as cathode. Platinum will not dissolve if feeble currents are used.

The results, given above, leave no doubt as to the applicability of this method in the estimation of gold.

Subsequent efforts were directed to its separation from other metals. As antimony can be deposited from a sodium sulphide solution by a current giving 1·5-2·0 cc. of OH gas per minute, I made no attempt to separate it from gold. The separation of gold from tin was much desired. Numerous trials were made. The results, however, were unsatisfactory. The gold was, in all instances, precipitated, but it carried down with it from one to three per cent. of tin. The sodium sulphide, in these separations, showed a specific gravity of 1·21. An additional gram of sodium hydroxide was introduced into the electrolyte for every centigram of metallic tin present. The current did not exceed 1·5 cc. of OH gas per minute. The dilution with water was 100 cc. While these conditions were exactly analogous to those in which antimony is separated from tin, they failed in the case of gold and tin.

Gold from Arsenic.—(1) The solution electrolysed contained 0·1446 gram of gold, as chloride, 20 cc. of sodium arsenate solution (= 0·15920 gr. metallic arsenic), 60 cc. sodium sulphide, and 100 cc. of water. The current gave 1·2 cc. OH gas per minute. It ran through the night. The washed and dried deposit of gold weighed 0·1443 gram.

(2) With conditions similar to those in (1) the gold weighed 0·1446 gram.

Gold from Molybdenum.—(1) 0·1437 gram of gold, as chloride, 0·1500 gram molybdenum, as ammonium molybdate, 40 cc. of sodium sulphide, and 120 cc. water were exposed to the influence of a current giving 0·7 cc. OH gas per minute. The time of deposition was twelve hours. The gold weighed 0·1430 gram.

(2) 0·1178 gram of gold, as chloride, 0·1200 gr. of molybdenum, 30 cc. of sodium sulphide (sp. gr. 1·12), and 100 cc. of water were electrolysed with a current giving 2 cc. OH gas per minute.

The precipitated gold weighed 0·1172 gram. The current acted ten hours.

Gold from Tungsten.—(1) 0·1437 gram of metallic gold, as chloride, 0·1500 gram of tungsten, as ammonium tungstate, 20 cc. sodium sulphide (sp. gr. 1·17), and 100 cc. of water, gave 0·1440 gram gold, when electrolysed with a current generating 1 cc. of OH gas per minute. The precipitation required 12 hours.

(2) In this trial 0·1440 gram of gold was found. The conditions were analogous to those of (1).

The gold deposits in all of the separations were bright and compact. The same manner of washing and drying was pursued as in the first determination of the metal.

Gold was never discovered in the liquid removed from the deposit.

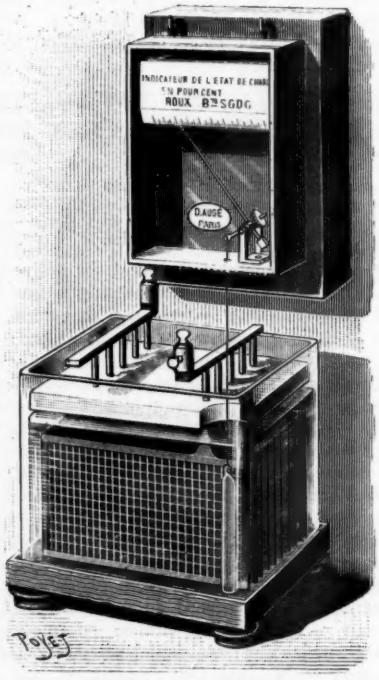
Qualitative trials proved that the separation of gold from vanadium, under conditions similar to those already mentioned, was also possible.

Chemical Laboratory of the Univ. of Pa.,
Philadelphia, *February 13th*, 1891.

GASTON ROUX'S CHARGE INDICATOR.

UNTIL now, no apparatus has been constructed for showing the state of charge or discharge of an accumulator by a direct reading. This want has now been supplied by M. Roux, the head of the department of practical electricity at the *Ecole de Physique et de Chimie Industrielles*, Paris, who has invented the apparatus which is shown in the accompanying figure, and the perfect working of which is equalled by its great simplicity.

This indicator is based on the variations of density in the electrolytic liquid, according to the different conditions of charge or discharge of the element, a principle indicated in



1883 by M. Sellon, and the practical application of which was attempted by Mr. Parker, in 1886, but without success, since the apparatus which formerly figured in the catalogues of Messrs. Woodhouse and Rawson has no longer a place in commerce. From the experiments undertaken first by M. Roux, it follows that for densities between 1·15 and 1·35, and temperatures between 0° and 30° Centigrade, the mean density of the electrolytic liquid of an accumulator is in proportion to the quantity of electrical energy stored up. This fact being ascertained, it remained to construct an instrument indicating this mean density in order to deduce from it at any moment the state of charge of the accumulator. In order to determine this mean density, taking into account the non-homogeneousness of the liquid, the densimeter consists of a half-round tube the length of which is equal to the height of the liquid, and which is suspended from a platinum wire $\frac{1}{10}$th of a millimetre in diameter, thus constituting a constant volume areometer. The measurement of the mean density of the liquid, therefore, amounts merely to the determination of the push received by the tube. The glass tube is heavier than the push it receives from the liquid and remains suspended from the extremity of a little lever oscillating round a horizontal axis. This lever arm is

horizontal when the push is greatest and the accumulator charged to saturation point; it makes an angle of 45° when the accumulator is completely discharged. Two weights fixed on two rods on which a screw thread is cut, one of which is in the prolongation of the little lever arm to which the densimeter is suspended, and the other making an angle of 45° with this lever arm, enable the apparatus to be adjusted once for all in its two extreme positions, which are indicated by a long balanced needle, moving along a horizontal scale divided into 100 equidistant parts, the needle passing behind the scale. The theory of the apparatus, into which we will not enter here, shows that for an instrument established under these conditions, the displacements of the needle along the horizontal scale are in proportion to the variations in the density of the liquid, and, consequently, to the quantities of electricity successively added to or drawn from the accumulator.

If the instrument is set once for all at 0 when the accumulator is discharged and at 100 when it is completely charged, the position of the needle shows, by a direct reading, the charge remaining in the accumulator, this being expressed in parts of 100. It is moreover easy, by providing the apparatus with two electric contacts, to transform it into an automatic recorder of the charge or discharge, one of the contacts being arranged to close the circuit of an electric bell on the accumulator when the needle is at 90 or 95, and the other closing the circuit of the bell when only 15 or 20 per cent. of the charge remains in the accumulator.

A single indicator is sufficient for a battery of similar elements charged or discharged at the same time, which is the case in the greater number of installations, but, practically, it is preferable in an installation of importance to employ two for two elements chosen at random in the series, these two being placed where the apparatus can most conveniently be examined.

A personal experience of several months enables us to affirm that M. Roux's apparatus is perfectly practical, easily installed, requires no maintenance, and is capable of rendering important services in all electrical installations in which accumulators are employed. C. G. S.

ON THE DESIGN OF ALTERNATING CURRENT MOTORS.*

By A. H. WESTON.

A series of experiments and investigations, conducted for some time past by myself, leads me to believe that the alternating current is as applicable to the purposes of power as the constant current, but that certain definite conditions must be observed in the design of alternating current motors which do not come into consideration at all in a constant current motor. It is true, I have, so far, experimented only with small motors, but I believe that large self-regulating motors can be constructed according to the same principles, to operate successfully.

In dealing with the alternating current, one of the most important things to be considered is the self-induction which the current tends to set up, producing an E.M.F. contrary and inimical to its own E.M.F. This self-induction, which is the attribute of the dynamic nature of the alternating current, always acts to destroy or neutralise the current which sets it up. In exactly the same manner does the expansion of steam, or other vapour, whose force of expansion is due to heat, and by means of which expansion it does its work, consume or neutralise the heat which produces the force.

Now in making an alternating current motor it is necessary to dispose the windings on the magnetic circuit so that the value of the self-induction will vary as nearly as possible inversely as the work done by the motor. I believe that this condition can be approximated, if not exactly attained, by having due regard to the magnetising and mutual inductive effects of the windings on the armature and field.

Let us consider the behaviour of two similar coils of equal magnetising effect, wound upon a simple magnetic circuit. Fig. 1 shows such an arrangement. In all cases we will assume that the magnetic circuit is thoroughly laminated in the direction of the lines of force, as that is, of course, always necessary. If an alternating current is caused to flow through the coil, A, having at any instant the polarity indicated, there will appear in the coil, B, if the circuit of the same is completed, a current of opposite polarity, as indicated, which will vary with the resistance of the circuit. If the coil, B, remains open so that the resistance through its circuit

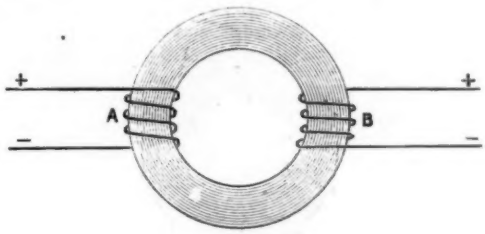


Fig. 1.

is infinite, the self-induction produced by the current in the coil, A, will react against the said current, and, if the inductive properties of the iron were perfect, would cause a counter E.M.F. equal to the original E.M.F. producing the current and check it altogether. This is, in general, the action of the converter.

If we impress upon the coil, B, an E.M.F. similar to the E.M.F. producing the current in A, but reversed in direction to that shown in fig. 1, we will experience the same result as in our last experiment, only *more so*, so to speak. If, on the other hand, we cause the same alternating current or similar currents to pass through each coil in the direction indicated in fig. 1, it will not only be found that the self-induction will be entirely eliminated, but if the E.M.F. is maintained the same at the terminals of each coil, the current flowing through each will be proportional to the sum of the two E.M.Fs.

Let us now divide the magnetic circuit of the iron ring by establishing a magnetic path across the ring, as shown in

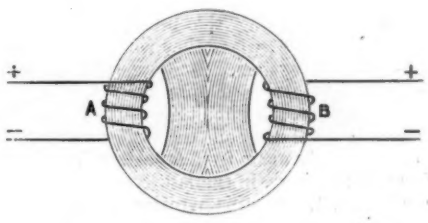


Fig. 2.

fig. 2, and cause the current to pass through the coils in the direction shown. What will be the result? We will now find the self-induction present in full force, as in the case of the transformer with an infinite resistance in the secondary circuit. Both coils now co-operate to project the lines of force across the centre path in the same direction. This is the condition which would exist if we were to consider the ring as a motor field and place an inert armature within the ring.

If we now consider the nature of an armature apart from its field, such as the ordinary form of Siemens drum armature or Gramme ring, we will readily see that, supplied with current from two brushes set at diametrically opposite points of a commutator, it can be considered for the purposes of this discussion as similar to the system shown in fig. 1, but better shown in fig. 3. That is to say, apart from the field, in a non-magnetic medium, such as air, an alternating current will encounter no impedance in passing through the windings, save that due to one-quarter of the whole ohmic resistance of the coils. If, however, we place it in an inert field, as shown in fig. 4, we provide a magnetic path from one side of the system to the other, producing the same condition in the armature as we have in the field in fig. 2, only that the path is external, instead of internal. In this case the magnetising effect of the armature coils tends to project the lines of force across this external path in the same direction, and this produces self-

* New York *Electrical Engineer*.

induction in the armature coil which checks the current, as in the last case considered, of the field.

Fig. 4, it will be seen, is perfectly analogous to fig. 2, excepting that in fig. 4 we have the means of causing magnetic energy in the centre path, *per se* inert in fig. 2. We will now cause an alternating current to pass through the field coils in the direction shown in fig. 4 and a like current to pass through the armature coils so that the mag-

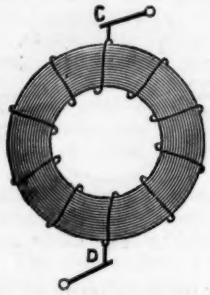


FIG. 3.

netic forces of all the coils tend to project the lines of force through the armature path in the same direction. The self-induction will now attain its maximum value in all of the coils and the system, so arranged, will be practically opaque to the passage of current, as in the third case considered in connection with fig. 1. In this condition the armature will have no tendency to revolve, as the magnetic current defined by the magnetising forces of the field and armature coils will be the shortest circuit possible through the system and the forces between the field and armature will be in equilibrium. The points of contact of the brushes with the commutator will now coincide with the polar line, C D, of the field and armature. This, theoretically, will be the condition under which a perfect motor will work with no load. By this, I do not mean that the brushes would necessarily be at this point. They might, or might not, be.

The last to be considered is the case wherein the magnetising force of the armature is reversed, which can be accomplished by swinging the brushes, as last connected, through an arc of 180°, where they will again coincide with the polar line of the system. Here we have the magnetising forces of the field and armature coils tending to project lines of force around the circuit in opposite directions and we will have in all of the coils the same condition as we had in the armature coils apart from a field, or in the field coils apart from an armature, in the last case considered in connection with fig. 1. In this position an excessive current will pass through the coils and the armature and field will be in a condition of neutral instability. The slightest displacement of the armature in either direction will give it ten-

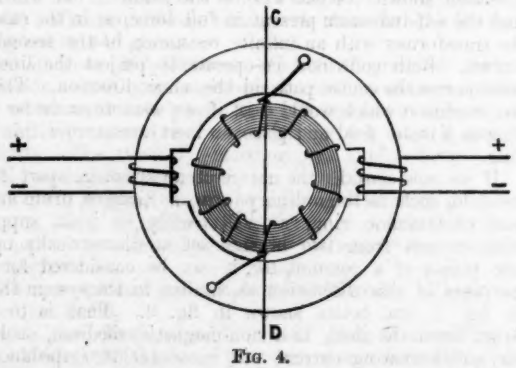


FIG. 4.

dency to move in that direction. In popular language, it would move by repulsion.

It will now be readily understood that there will be a position of the brushes between these extreme positions where the resultant opposing magnetic force of the armature will create a "reluctance" in the armature portion of the magnetic circuit, less than the reluctance which would result from the removal of the armature altogether, leaving only an air space, and greater than the reluctance of an inert magnetic path, such that the self-induction of the coil would just be eliminated.

This is, theoretically speaking, the desired condition, although practical considerations of regulation might dictate some departure from this. By making the magnetic force of the armature coils of sufficient magnitude, this condition can be attained at the point where the brushes will give the most effective torque to the armature. With the armature clamped in this position the current will experience only the ohmic resistance of the coils and the motor will take its maximum current, which will produce a powerful directive tendency in the armature to revolve.

The acceleration of the armature in its attempt to restablish equilibrium will cause a diminution of the opposing force exerted by the armature coils, which causes a rise in the self-induction and counter E.M.F. in the coils, and by a proper utilisation of this property the motor will be self-regulating for speed under varying conditions.

Now a word about the relative magnetising forces of the field and armature coils. We know it is the practice in constant current motors to make the magnetising force of the field greatly preponderate over that of the armature and the armature core takes its resultant magnetic complexion from the field. It can readily be seen that this will not do at all for an alternating current motor, as the armature must be able to outweigh the field in magnetising power. As a rough approximation, we will say that the effective magnetising force of the armature coil must be equal to that of the field coils. As the effective magnetising force of the armature coils is not the whole magnetising force represented by the ampère turns of its coils we must make due allowance therefor.

The relation which the effective magnetising force bears to the magnetising force is as follows :—

Let M = the total magnetising force of the armature turns, and m the effective force. Then $\frac{m}{M} = E$; E being the average value of sin β between 0° and 90°.

As $E = \frac{2}{\pi}$, if we find that the magnetising force of the armature must be n times that of the field, letting N represent the number of ampère turns on the field, and C the number of ampère turns on the armature, it follows that

$$C = \frac{\pi N n}{2},$$

which will give us the required effective magnetising force in the armature.

In designing the field of an alternating current motor it will readily be seen from the above that the coils must be so disposed upon it as to counteract their self-induction when the proper degree of "reluctance," or permeability, is produced in the armature portion of the magnetic circuit. That is to say, the field should form a divided circuit in connection with the armature, the coil turns being equally distributed on each division. It would be perfectly possible to embody the above principle in a multipolar motor and armature, and I have selected the bipolar type for illustration only as being less complex in its nature.

The type of field which I consider best adapted for alternating current motors is the simple ring circuit shown in figs. 1, 2 and 4. Of course, other modifications may be used which would answer practically as well, but this seems to me to be the simplest and most ideal form.

Rotation of the armature can also be secured by short circuiting the two brushes instead of causing a current to flow through the armature coils. The current in the armature coils will then arise from the inductive influence of the field and the proper "reluctance" may be produced by swinging the brushes around to the proper position relative with the field, which will change the direction of the magnetising effect of the armature coils.

I have watched with much interest the labours of several able experimenters in the direction of designing a motor without the usual form of commutator for the revolving element. While there is no doubt that such a motor is a thing greatly to be desired, I have come to the conclusion, after a careful analysis of the whole subject, that with a current of only one phase, that is to say, without transforming the phase of the current by some means, we must accept the commutator as a necessary function of continuous revolution.

ON ELECTROSTATIC SCREENING BY GRATINGS, NETS, OR PERFORATED SHEETS OF CONDUCTING MATERIAL.*

By Sir WILLIAM THOMSON, D.C.L., P.R.S.

I. *Grating.*

1. Maxwell, in his "Theory of a Grating of Parallel Wires" ('Electricity and Magnetism,' Arts. 203—205†, and Plate XIII.), gives a very valuable and interesting two-dimensional investigation of electrostatic screening, and a most instructive diagram of "Lines of Force near a Grating," which powerfully helps to understand and extend the theory, and to acquit it of an accusation wrongly made against it in the last two sentences of Art. 205. It is only on the supposition of the grate-bars being circular cylinders that the investigation is less than rigorous: and that supposition nowhere enters into the investigation; it merely appears in the word "radius," in the first line of the last sentence but one of Art. 204, and it is contradicted in lines 3 and 4, and by the rest of the sentence, and by the next sentence. (See § 6 below.)

2. The conclusion, "$a = -0{\cdot}11\ a$," in the last sentence of Art. 205, condemned as "evidently erroneous," is quite correct, and very interesting. It shows that a corrugated metal plate agreeing with the equipotential surface $c = \frac{1}{2}a$, exceeds in electrostatic capacity a plane metal surface through the poles of the diagram (Plate XIII.), with the surroundings described in Art. 204, and supplies the datum requisite for finding the exact amount of the excess. The reason for the greatness of the excess clearly is that the surface $c = \frac{1}{2}a$, which just touches the plane through the poles of the diagram midway between the poles, is everywhere nearer than this plane to the other plate of the condenser. (See § 7 below.)

3. For $c = a/6$ we have, by (11) of Art. 205, $a = 0$, and the corresponding equipotential, partially shown in Maxwell's diagram, is a set of curves concave towards $z = -\infty$, and asymptotic to the lines $x = (i \pm \frac{1}{2})\ a$, i denoting any integer. (See §§ 10 to 13 below.) For every value of c less than $a/6$, the equipotential is a row of ovals; and the grating formed by constructing these ovals in metal has less electrostatic capacity in the circumstances described in Art. 205 than a plane through the poles or the ovals (this being no doubt what is meant by "a plane . . . . in the same position" as the grating).

4. For every value of c exceeding $a/6$ the equipotential, instead of being the boundary of a grating, is a continuous corrugated surface, and its electrostatic capacity exceeds that of the plane through the poles.

5. Begin now afresh, and let it be required to find the electric force in the air on either side of an infinite row of parallel bars at equal consecutive distances, a, each uniformly charged with electricity. Let $\rho\ a$ be the quantity per unit length on each bar, so that ρ would be the surface density, if the same quantity were uniformly distributed over the plane of the bars. Taking O in one of the bars, O X perpendicular to the bars, and O Z perpendicular to their plane, we find (by Fourier's method) for the z-component of force at any point (x, z) for which z is positive.

$$Z = \frac{4\pi\rho}{a}\left(\tfrac{1}{2} + \varepsilon^{-mz}\cos mz + \varepsilon^{-2mz}\cos 2mz + \&c.\right) \quad (1)$$

where
$$m = 2\pi/a \quad (2)$$

Summing this we find

$$Z = \frac{2\pi\rho}{a}\,\frac{\varepsilon^{mz} - \varepsilon^{-mz}}{\varepsilon^{mz} - 2\cos mx + \varepsilon^{-mz}} \quad (3)$$

This has equal positive and negative values for equal positive and negative values of z, and it therefore gives the value of the z-force, not only for positive, but also for negative, values of z. Taking now $-\int Z\,dz$, with constant assigned to make the integral zero for $z = \pm D$, we find

$$V = \rho a\left(\log\frac{1}{\varepsilon^{mz} - 2\cos mx + \varepsilon^{-mz}} + mD\right) \quad (4)$$

as the potential due to the grating, and two parallel planes at equal distances, D, on its two sides, each uniformly electrified with half the quantity of electricity of opposite sign to that on the grating.

6. If now we construct in metal, C, any one complete equipotential surface V_0, of this system, and electrify it with the same quantity of electricity as that which we gave originally to the infinite row of infinitely thin bars; and if we place metal planes, B, B′, at the two places of zero-potential ($z = \pm D$), we have an insulated conductor at potential V_0, between two planes, B, B′, at zero potential, and at distance $2D$ asunder, on each of which the electric density is $\frac{1}{2}\rho$. For brevity, I shall denote the insulated conductor by I.

Its electrostatic capacity per unit area of its medial plane (the plane of the original infinietly thin bars) is $\rho\ V_0$.

7. This conductor, I, is symmetrical on each side of its medial plane, and consists either of an infinite number of isolated parallel bars, each surrounding one of the original infinitely thin bars, or of a plate symmetrically corrugated on its two sides, with maximum and minimum thicknesses respectively at the places of the infinitely thin bars, and the lines midway between them. For the case of isolated bars, let $2c$ be the diameter of each, in the medial plane. Then, to find V_0, we must put $x = \pm c$ and $z = 0$, in (4). Thus we find

$$V_0 = 2\pi\rho\left(\frac{a}{2\pi}\log\frac{1}{4\sin^2\frac{\pi c}{a}} + D\right) \quad (5)$$

Hence the electrostatic capacity of I in the circumstances is

$$1 \Big/ \left\{2\pi\left(D + \frac{a}{2\pi}\log\frac{1}{4\sin^2\frac{\pi c}{a}}\right)\right\} \quad (6)$$

which is greater or less than $1/(2\pi D)$, the electrostatic capacity that it would have if reduced to its medial plane, according as $c >$ or $< \frac{1}{6}\ a$ (compare § 5 above). The conductor, I, to be a grating, implies $\sin^2\frac{\pi c}{a} < 1$, and therefore requires that

$$V_0 > 2\pi\rho\left(\frac{a}{2\pi}\log 4\right) = 2\pi\rho\,(D - {\cdot}22\ a) \quad (7)$$

When V_0 exceeds this critical value, the conductor, I, is the continuous plate corrugated on each side, which was described in § 7. The critical value corresponds to an intermediate case of a plate so deeply furrowed on each side as to be just cut through by its two surfaces crossing at right angles; and (7) shows that the electrostatic capacity of the conductor, I, so constituted is equal to that of a plane sheet of thickness

$$2\ a\log[2^2]/(2\pi), \text{ or } {\cdot}44\ a \quad (8)$$

insulated midway between the two earth plates, B, B′, at the same distance asunder as they had with I between them.

8. By (4), (5), and (7), we have for the equation of the surface constituting the two sides of I in this critical case,

$$\varepsilon^{-mz} - 2\cos mx + \varepsilon^{-mz} = \log 4 \quad (9)$$

Taking double the positive value of z which this gives when $x = 0$, we find

$$2\ a\log[(1 + \sqrt{2})^2]/(2\pi), \text{ or } {\cdot}562\ a \quad (10)$$

as the maximum thickness of I. This is $(1 + \sqrt{2})/2$, or 1·208 times the amount shown in (8) for the thickness of plane-sided plate of equal electrostatic capacity; which is just such a relation as is expected before calculation!

9. If $\phi(z, x)$ denote what V becomes when in place of mD we substitute $-mz$ in (4), we have the potential due to a uniform electrical force, $\rho\ a\ m$, or $2\pi\rho$, added to the z-component of the force due to the grating with its given charge of, $\rho\ a$, quantity per unit length of each bar; and it is the equipotentials and lines of force of this system that are represented in Maxwell's diagram of Plate XIII. reproduced here. In it the resultant force for infinitely large positive values of z is parallel to O Z, and of constant value $4\pi\rho$; and it is zero for infinitely large negatives values of z. The approximation to these values is very close, at only so moderate a distance as a on either side of the grating.

10. Choosing, in this system of section 6, any one of the multiple-oval equipotentials around the infinitely thin bars, that indicated by the shading, for example, which I have

* Read before the Royal Institution.

† In formula (7) of Art. 204, delete λ; in Art. 204, delete 2 in last line of p. 250 (Edition 1873); and delete 2 in lines 6 and 16 from the foot of the page.

added to Maxwell's diagram, let c be the distance from the infinitely thin primary bar within it, at which it is cut by the plane of the primary bars. By putting in the expression for $\phi\,(z, x)$, $z = 0$, and $x = c$, we find

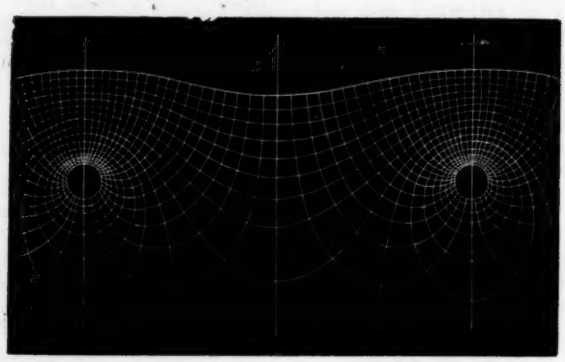
$$\phi\,(0, c) = \rho\, a \log \frac{1}{4 \sin^2 \frac{\pi c}{a}} \qquad (11)$$

as the potential at the surface of each of these chosen ovals. Construct now each of these ovals in metal, and let the supposed uniform force, $2\pi\rho$, be produced by uniform electrification of density $-\rho$, on a metal plane, B, at any great distance, b, on the positive side of the grating. We thus construct a grating of thick bars of oval-shaped cross section which, when electrified with the same quantity of electricity as that to which we gave initially to the infinitely thin bars, and subjected to the influence of the equal quantity of negative electricity on B, has $\phi\,(z, x)$ for potential through external space from B ($z = b$), to infinite distance on the other side of the grating ($z = -\infty$), and has for potential through all the portions of space within the surfaces of the grate bars the constant value expressed by (11). In this system the potential, for positive values of z great in comparison with a, is, by (4) with $-mz$ instead of $-m$ D,

$$\phi\,(z, x) \doteq -4\pi\rho z \qquad (12)$$

The difference of potentials between B and the grating is, by (6) and (5),

$$\phi\,(0, c) - \phi\,(b, x) \doteq 4\pi\rho \left(b + \frac{a}{4\pi} \log \frac{1}{4 \sin^2 \frac{\pi c}{a}} \right) \qquad (13)$$



Hence the electrostatic capacity of the mutually insulated system, B, and the grating of oval-shaped bars is equal to the capacity of a pair of parallel planes, B and a plane at a distance beyond the plane of the primitive infinitely thin bars equal to

$$\frac{a}{4\pi} \log \frac{1}{4 \sin^2 \frac{\pi c}{a}} \qquad (14)$$

11. If in (4) we put $-nz$ in place of m D, we have the potential of a system in which besides the electricity of the primary bars there is distant electricity such as all in all to give at great enough distances on the two sides of the primitive bars uniform fields of z-force respectively equal to

$$\rho(m + n), \text{ for } z = +\infty\,; \text{ and } \rho(m - n), \text{ for } z = -\infty \qquad (15)$$

If, in (4) with $-nz$ instead of $+mz$ D, we put

$$\epsilon^{-\mathrm{V}/\rho a} = \mathrm{C} \qquad (16)$$

we find, as the equation of the equipotential surfaces,

$$-2\cos mx + \epsilon^{mz} + \epsilon^{-mz} = \mathrm{C}\,\epsilon^{-nz} \qquad (17)$$

By taking $n = 0$, or $n = m$, we fall back on the cases of §§ 5—8, and §§ 9, 10, respectively.

12. To find an approximate equation for the equipotentials at distances around primitive bars small in comparison with a, the distance from bar to bar, let x and z be so small that we may neglect all powers of mx, mz, and nz, above the square, which implies that C is small of the same order as $(mx)^2$ and $(mz)^2$, (11) becomes

$$\left\{ x^2 + \left(\frac{z + \frac{1}{2} n r^2}{1 + \frac{1}{4} n^2 r^2} \right)^2 = r^2 \right\} \quad \text{where } r^2 \text{ denotes } m^{-2}\,\mathrm{C}^2 \qquad (18)$$

This shows that, to the degree of approximation in which we neglect cubes and higher powers of mx, mz, nz, the equipotential is a row of elliptic cylinders of eccentricity $\frac{1}{2} n r$, with the primitive bars of their foci and their greater diametral planes perpendicular to the plane of the primitive bars. When $n = 0$, the equipotential is a row of circular cylinders having the primitive bars for their axis; and this is true to the higher approximation, in which we need only neglect powers above the cubes of mx and mz, as we see by going back to equation (17), with $n = 0$.

13. The conclusions of § 12 are useful for detailed investigation of the screening effect of plane gratings of circular or elliptic, straight parallel bars electrified with given quantities of electricity and placed with their planes perpendicular to the lines of force in a uniform field of force, and to corresponding problems in which potentials are given, as in Maxwell's §§ 203—205.

14. Instead of a single row of parallel equidistant infinitely thin bars in one plane, let us take for primitives or foci, as we may call them, two or more such rows parallel or not parallel, all in one plane or not in one plane. We may thus form an endless variety of force-systems available for illustrating or helping to solve problems which may occur. Towards the several problems of electric screening we find important contributions by considering in two parallel planes rows of focal lines parallel to one another for one case and perpendicular to one another for another case. The consideration of three rows of focal lines in one plane, dividing it into equal and similar triangles alternately oriented in opposite directions, leads to a complete theory of electrostatic screening by a triangular lattice of metallic wire or ribbon. The fundamental potential formula for this system obtained by summation of expressions given, each by an application of (4), to one of the the three rows, is

$$\mathrm{V} = \log \frac{1}{(\epsilon^{lz} - 2\cos lp + \epsilon^{lz})^{\omega a} (\epsilon^{mz} - 2\cos mq + \epsilon^{-mz})^{\rho b}} \cdot \frac{}{(\epsilon^{nz} - 2\cos nr + \epsilon^{-nz})^{\sigma c}} + 2\pi(\omega + \rho + \sigma)\mathrm{D} \qquad (19)$$

where a, b, c, denote the intervals between the successive lines of the three systems, $\omega\,a$, $\rho\,b$, $\sigma\,c$, the quantities of electricity per unit length of bar in the three systems; p, q, r, z, special co-ordinates of the point for which (19) expresses the potential, viz., z, its distance from the plane of the focal bars, and p, p, r, its distances from three planes drawn perpendicular to this plane through a bar of each of the three systems; D the value of z for a plane for which the potential is zero, and, lastly,

$$l = 2\pi/a,\ m = 2\pi/b,\ n = 2\pi/c \qquad (20)$$

For the present, however, we may confine ourselves to the case of two rows of focal lines dividing a plane into squares and charged, both rows, with equal quantities, ρ, of elec-

tricity per unit length. The potential formula, a particular case of (19), is

$$v = \rho a \Big[\log \frac{1}{(\epsilon^{mz} - 2\cos mx + \epsilon^{-mz})(\epsilon^{mz} - 2\cos my + \epsilon^{-mz})} + 2m\,D \Big] \quad (21)$$

15. The consideration of the equipotentials of this surface is very interesting, and is illustrated by a model submitted to the Royal Society. The equipotential lines in the plane of the focal bars given by the equation

$$16\left(\sin\frac{\pi x}{a}\sin\frac{\pi y}{a}\right)^2 = \epsilon^{-v/\rho a} \quad (22)$$

are shown in the accompanying diagram of curves.

16. Considerations quite analogous to those of §§ 6, 7, 8, and again the other considerations analogous to those of §§ 9—13, are, after the full explanations there given, easily completed so as to formulate a full theory of electrostatic capacity and electrostatic screening for square nets of wire exposed to electric action giving uniform fields of force at distances on each or on one side of the plane of the net, considerable in comparison with a, the side of each square.

17. In what follows we shall for brevity call any thin sheet, whether plane or not plane, which answers to the description contained in the title of this paper, a *porous sheet* or a *porous surface*; understanding that its radii of curvature are everywhere large in comparison with its thickness. The diameters of pores may be large or small in comparison with the thickness. We shall call the electric density of a porous sheet the total quantity of electricity with which it is electrified, reckoned per unit area of continuous surface approximately agreeing with it.

18. In what precedes we have virtually a complete investigation of the screening effect of a homogeneous plane porous sheet against the electric force of a uniform field with lines of force perpendicular to the plane. Let it now be required to find the screening effect of a non-plane porous sheet against a uniform field of electrostatic force, and of a porous sheet, S, plane or not plane, against the electrostatic force of any given electrified bodies.

19. Let ϕ be the potential of the given electrified bodies at any point (x, y, z) of the space occupied by S, and let ρ be the unknown electric density of S at (x, y, z), under the influence of those bodies. To make the problem of finding ρ determinate, we might suppose either the total quantity of electricity on S, or the potential, C, at which its metal is kept, to be given. We shall take the latter supposition, and call the given potential C.

20. Let ϕ denote the potential which would be produced by the electricity of S if it were spread continuously over a continuous surface agreeing with S, with electric density equal to ρ at (x, y, z), and let

$$\phi + \mu\rho \quad (23)$$

denote the potential in the metal of S, due to the actual distribution of electricity on its surface.

21. To understand the meaning of this notation, μ, consider a large area around (x, y, z), so large that its border is very distant from (x, y, z) in comparison with the thickness of the sheet, and with the diameters of its apertures, but not so large as to deviate sensibly from the tangent plane at (x, y, z). Let the electricity of all the surface of S beyond A be changed from the imagined continuous distribution to the actual distribution on the surface of the perforated metal. This change will make no sensible difference in the potential at (x, y, z). Next, let the imagined continuous distribution of uniform electric density, ρ, over the continuous area, A, be changed to the actual distribution of the same quantity over the surface of the perforated metal of the porous sheet, A. The augmentation of potential at (x, y, z) is what we denote by $\mu\rho$, where μ is clearly a coefficient depending on the shapes and magnitudes of the perforations, that is to say, on the complex surface of the perforated metal. It would be zero if there were no perforations, and we shall see that the greater it is the less is the screening efficiency. We shall therefore call μ the electric permeability, and μ^{-1} the electric screening efficiency of the porous sheet. The sheet is homogeneous as to the permeability or screening efficiency if μ has the same value for all parts of it, but we need not assume this to be the case; on the contrary, we shall suppose μ to be any known function of (x, y, z). In §§ 5—16 we have the explanations necessary for determining μ in the various cases of gratings and nets there described.

22. The equation of electric equilibrium is

$$\phi + \mu\rho = C \quad (24)$$

[Solutions for spherical and cylindric surfaces follow.]

THE DE MÉRITENS BATTERY.

Our readers are already acquainted with the paper sent by M. de Méritens to the International Society of Electricians at their meeting on the 4th of February last.* This paper gave rise to criticisms presented by various members of the society at the meeting on the 4th of the following month, at which meeting M. de Méritens was unable to be present.

We take the following criticisms from the Bulletin of the Society:—

M. Hospitalier.—The communication made by M. de Méritens at our last sitting on the "Galvanic Battery in Industry" has been the subject in the political press of several highly eulogistic articles. Without attaching to these articles greater importance than they possess, we will now deal only with M. de Méritens's paper, and we will bring against his assertions the results of experiments made at the Ecole de Physique et de Chemie Industrielles, Paris, upon an element supplied to us by M. de Méritens, he having charged this element himself, and followed its working for the first few hours. As we said at the last sitting, contradicting M. de Méritens, the electromotive force of the element is only ·8 of a volt and not 1·3 volts; and besides, as the diluted sulphuric acid is exhausted, this force falls to ·75 of a volt. It is true, that at the commencement, with new carbons, it is possible to obtain ·8 volt. We remember that in 1885, M. Jablochkoff obtained 1·8 volts from his chloride of calcium battery, by first soaking his carbons in nitric acid, ... to *clean* them. In M. de Méritens's battery, where nothing but sulphuric acid and zinc is used, we cannot obtain either theoretically or practically more than ·8 of a volt. This is what we have found.

Under the conditions of maximum available power, a similar battery would thus give only ·4 of an effective volt; but by increasing the external resistance, the output is diminished, while the rendering is increased, and ·5 of an effective volt can be obtained per element, or 2,000 ampère hours per kilowatt-hour, which corresponds to an expenditure of 2,460 kilogrammes of zinc and 6 kilogrammes of sulphuric acid per kilowatt-hour. Estimating the zinc at 70 francs per 100 kilogrammes, and sulphuric acid at 10 francs per 100 kilogrammes, we arrive at an expenditure of 2·35 francs per kilowatt-hour, whereas the central stations only charge the consumers of electrical energy half that sum. The cost prices vary between 30 and 80 centimes, according to the local circumstances, the daily consumption, the price of carbon, taxes, &c. As regards constancy, the element experimented upon when discharged over an external resistance of ·1056 of an ohm, gave a quantity of electricity equal to 63·1 ampère-hours, which corresponded to all intents to half the sulphuric acid contained in the 1,500 cubic centimetres of solution. The current varied between 5·65 and 4·8 ampères, and the available power between 4·25 and 2·2 watts. These variations are sufficient to prevent the direct application of the battery for lighting purposes, and they would have been still greater if the exhaustion of the acidulated sulphuric solution had been carried further.

In the case in which the zinc is to be electrolysed in order to be used again, it follows from our experiments that the polarising electromotive force of the electrolytic zinc-iron bath is about ·5 of a volt, and that it would be necessary to supply at least ·6 to ·7 of a volt in order to introduce a current of sufficient intensity. Under these conditions, the electrolysis of the sulphate of zinc would require from a steam engine working a dynamo more energy than the battery would have furnished in the first period of its term of working. We should thus, at the utmost, realise only a

* The "Galvanic Battery in Industry."—Electrical Review, February 20th, 1891.

second rate accumulator, wanting in constancy and in simplicity, requiring more or less complicated manipulations to enable it to pass from the period of charge to the period of discharge, and giving an insignificant effective difference of potential.

We can only speak from memory of the utilisation of the hydrogen gas produced by the battery while at work, this utilisation being impossible in the greater number of applications.

In order to ascertain the advantage gained by the use of the platinised lead covering the carbon electrodes, we made a second experiment with the same zinc and the same carbons, under the same conditions of available circuit. The output was a little diminished in consequence of a slight increase in the internal resistance, but the constancy of the output was maintained during a longer period. It would be easy to obviate this increase of resistance by surrounding the plate of carbon with a frame of melted lead. The consumption of zinc was rather greater than that indicated by the theory, the plate of zinc not having been re-amalgamated in this second experiment.

A third experiment was made with the same plates of carbon, substituting some ordinary amalgamated zinc for M. de Méritens's pure amalgamated zinc. The actual consumption far exceeded the theoretical, showing that ordinary zinc could not be employed with this battery, which would again increase the cost price calculated above, for pure zinc costs 140 francs per 100 kilogrammes instead of 70 francs.

In short, M. de Méritens's battery presents no special advantage of a nature to warrant the enthusiastic reception it has met with, and makers of dynamos have no cause to fear from this battery a rivalry which only exists in the imagination of its promoter.

M. PICOU: M. de Méritens's paper contains also in the part not relating to electricity grave errors which it is impossible to overlook. These relate to the hydrogen given off and the motive force that can be obtained from it. M. de Méritens says:—*1 kilogramme of hydrogen represents about 14 cubic metres of gas, the atmospheric air being* 1.

The first error arises from a confusion between the density as compared to air and the specific weight. Hydrogen is quite 14 times as light as air, but the latter weighs 1·293 kilogrammes the cubic metre, so that the kilogramme of hydrogen occupies only 11·25 cubic metres and not 14.

The other error is much more serious and is difficult to explain. *One cubic metre of pure hydrogen*, says M. de Méritens, *employed in a gas motor, gives about three steam horse-power*. Now, the steam horse-power hour is equal to 270,000 kilogrammetres or 635 calories. Three horse-power hours are thus equal to 1,900 calories.

The kilogramme of hydrogen occupying 11·25 cubic metres is capable of developing, while burning, 34,000 calories. The cubic metre, therefore, can only give at the most 3,020 calories.

If out of these 3,020 calories 1,900 can be transformed into mechanical work, the gas motor would have a *total rendering* (the product of the thermic rendering by the organic rendering) of ·63.

This would be marvellous, but unfortunately it is very far from being the fact.

According to M. Witz,* the *thermic rendering* alone of the Otto compression motors is only ·38. Moreover, this value must be multiplied by the *organic rendering* which, according to M. Wehrlin,† does not practically exceed ·38, let us say ·4.

The total rendering of the gas motor, therefore, does not exceed ·15, instead of amounting to ·63 as estimated by M. de Méritens.

In some recent experiments performed, with the greatest care at the Conservatoire by Prof. M. Hirsch,‡ he obtained, from a motor of 16 H.P., the horse-power hour by means of an expenditure of 600 litres of gas. Estimating the latter at 5,300 calories per cubic metre, he deduced from it a maximum rendering of ·20. It is hardly necessary to remark that in the industrial world such good results are not obtained.

Keeping to the value ·15, we conclude from it that the cubic metre of hydrogen does not give three horse-power hours, but only ·715 or $\frac{4}{7}$ths of a horse-power hour, and that the kilogramme does not yield 42, but only 8.

M. SERRIN (HENRI): The electrolytic treatment of the sulphate of zinc by employing an anode of iron, as suggested by M. de Méritens, has one great objection. In the course of the year 1890, I, with the help of M. Archereau, made several experiments on this subject. The deposit of zinc, which at first is very bright and very pure, becomes gradually alloyed with iron, seeing that the solution is charged with sulphate of iron, and that the iron and zinc are deposited simultaneously. Notwithstanding all our efforts, we found it impossible to overcome this difficulty.

At the meeting of April 1st, on the occasion of the report of the preceding sitting, M. Hospitalier called attention to the fact that in the *Bulletin*, the text of which we have already quoted, after the phrase, "a fait l'objet, dans la presse politique, de nombreux articles fort élogieux," the words. "articles dont on connait la valeur et le prix" have been omitted, and he asked that they may be inserted, so that it may not be supposed that he had uttered words that he should not have said in the presence of M. de Méritens.

The President allowed this, and gave M. de Méritens permission to speak. The latter then replied as follows:—

Gentlemen, I had done M. Hospitalier the honour of believing that he had suppressed of his own accord the phrase which he has just publicly asked to be restored. This phrase is as follows:—"Eulogistic articles on the battery presented by M. de Méritens have appeared in the daily papers; if we do not admit their value we at all events know their price."

This is the first time that a scientific discussion has taken such a form before this society.

The ill-feeling towards myself is evident. But in thus injuring the reputation for courtesy which has hitherto been attached to the deliberations of the International Society of Electricians, M. Hospitalier has shown himself wanting in respect towards the President and towards you all, gentlemen.

When he substitutes abuse for scientific argument, he gives you, beforehand, a proof that he will not be impartial, and certainly he has not been.

M. Hospitalier says, quite correctly, that some experiments have been made at the School of Physics and Chemistry, Paris, on an element supplied by myself and mounted by myself, and that I followed its working for the first few hours.

But M. Hospitalier has forgotten to mention the constants which were found in my presence, and which I wrote down at his dictation. They are as follows:—

The element consisted of 1 plate of zinc about 1 decimetre square. At the beginning of the experiment the output was 6·5 ampères; when I left it was 6·4 ampères. The electromotive force in work was at the beginning ·64 of a volt, and at the end ·65 of a volt. This is what was found in my presence, *i.e.*, an electromotive force in work more than 30 per cent. higher than that announced by M. Hospitalier.

I do not know what took place after my departure; I only speak of what I saw myself.

As in such a case one ought not to speak without proof, here is an element working before your eyes. It gives, I believe, an output of 12 to 15 ampères. On this being tried the intensity was 9 to 10 ampères, and the electromotive force nearly ·8 of a volt.

I request the President to be kind enough to appoint one of our colleagues to test what I say. It is easy to obtain, with this element, and you have the proof of what I say before your eyes, an available electromotive force of ·7 of a volt as a minimum. Under these conditions the consumption of zinc per horse-power hour is 1,200 kilogrammes, or rather less than half the quantity indicated by M. Hospitalier, viz., 2,460 kilogrammes.

My opponent finds fault with my element on the ground that the output and the electromotive force diminish with the consumption of the sulphuric acid. This drawback is common to all possible voltaic combinations, and even to steam generators, which cease to supply steam when there is no more coal.

As regards constancy, it is evident that as the sulphuric acid is consumed, the constancy diminishes, and for this reason I took care to introduce into the element an organ

* "Etudes sur les Moteurs à Gaz Lonnant," by A. Witz.
† "Les Moteurs à Gaz à l'Exposition Universelle de 1889," by Ch. Wehrlin.
‡ "Annales du Conservatoire," 2nd series, Vol. II., 4th column.

calculated to keep the liquid at the same degree of acidulation. Thus there is absolute constancy for from 25 to 30 hours. M. Hospitalier determined the constancy of the element after having refused to make use of this arrangement. Naturally, he obtained a very variable constancy. In this case it was not my element that he experimented upon, but a modification of it created to suit his purpose.

As to the calculation made by my opponent to prove that the re-formation of the zinc by the electrolysis of its sulphate by means of a soluble anode of iron is of no advantage, they are evidently wanting in accuracy, since they are based upon the supposition that the maximum available electromotive force is ·5 of a volt, whereas, in my element, it is really ·7 of a volt; *i.e.*, 40 per cent. greater.

M. Hospitalier wished to know the object of the platinised lead covering the carbon electrodes :—

"*We made*," says he, "*a second experiment with the same zinc and the same carbons under the same conditions of available circuit. The output was a little diminished in consequence of a slight increase in the internal resistance, but the constancy of the output was maintained during a longer period.*" This result is not peculiar to the element experimented upon. The less steam is given off the longer does the fuel last. "It would be easy," adds M. Hospitalier, "*to obviate this diminution in the output and increase of resistance by surrounding the plate of carbon with a frame of melted lead.*" If I understand rightly, this means that it would have been better not to destroy my lead-carbon or lead-platinum couple, as it would have to be reconstructed afterwards in order to reap the same benefit from it. M. Hospitalier proves that he has recognised the use of the platinised lead covering the carbon electrodes.

In short, Gentlemen, I have no reason to alter the figures which I had the honour of submitting to you on the 4th of February last, relative to the electromotive force, the output, and the constancy of the element I submitted to your notice. My figures are under the truth. In my opinion, the fact of avoiding polarisation in an element with one liquid alone, obtaining all the electrical energy required, with complete constancy and under conditions of economy not realised by any other voltaic combination, is worthy of your attention.

The observations made by M. Picou, besides being expressed in a more Parliamentary style than that used by his predecessor, have also more foundation. If it is true that a kilogramme of pure hydrogen can furnish three and a-half times as many calories as a kilogramme of lighting gas, I was not correct in saying, as I did in my communication of February 4th, that a cubic metre of pure hydrogen gives three and a-half times as many calories as a cubic metre of lighting gas. M. Picou has called attention to my error, and he is right.

M. Serrin, together with M. Archereau, made in the course of the year 1890 several experiments in order to arrive at the extraction of zinc from the sulphate formed in galvanic batteries. These gentlemen, after several attempts, were not able to succeed in preventing the iron from being deposited on the cathode at the same time as the zinc. With all due respect to their competency, which I have pleasure in acknowledging, the fact that they were not able to find the solution of the problem does not prove that this solution is not to be found. I have here some samples of zinc extracted from the sulphate in the batteries by my own process. If it were impossible to arrive at a good result these samples would contain iron, but there is no trace of it in them.

M. Hospitalier : Gentlemen, in the first place I wish to refute the accusation of ill-feeling. I merely wished to perform an act of honesty in calling attention to the phrase which I had used in the absence of M. de Méritens, for it might have been thought that I dared not repeat it before him.

I was led to say what I did of the journals by the paid enthusiasm with which this communication was received.

We will now come to another question which concerns M. de Méritens himself. He accuses me of partiality. It is not being partial to bring before you results found, not by myself but by my pupils. We cannot be accused of partiality in a matter respecting the formation of financial companies, as neither my pupils nor myself have ever formed any.

I maintain what I said, viz., that we could obtain ·8 of a volt at the beginning of the experiment with good new carbons, but that the electromotive force had diminished with the consumption of the acid in consequence of the formation of the sulphate of zinc. This is true, and I regret not having the curves with me which I brought at the last sitting, and which are now being engraved for publication in the bulletin of the pupils of the school.

I maintain the accuracy of the results obtained at the school, and summed up in my communication, the experiments having been made with instruments incomparably more exact than those of M. de Méritens, who measures electromotive force with a Desruelles voltmeter, giving a deviation of 3 to 4 millimetres per volt.

To settle the matter, I request that the experiments be made again at the Central Laboratory, and that a battery be sent to M. de Nerville, who will not, I think, be accused of partiality by M. de Méritens, as he has not taken part in the present discussion. We shall see on which side the truth lies, after the examination of the results obtained at the Central Laboratory, both as regards the constancy and the consumption.

After a few more remarks, and at the request of the President, M. de Méritens consented to send a battery to the Central Laboratory to be experimented upon.

LONDON COUNTY COUNCIL.

At the last weekly meeting the Highways Committee reported as follows :—

Electric Lighting—Provisional Orders, 1891.

On the 13th of January last we reported to the council in general terms upon the new model form of provisional order, issued by the Board of Trade; and the council, upon our recommendation, gave instructions that the Board of Trade should be informed that the council desired various amendments of detail so as to make particular orders correspond in substance with the principal orders granted last session, leaving these details to be settled when the orders were deposited.

We have now had under consideration a number of orders forwarded by the Board of Trade, of which the following is a list :—

(*a*) Wandsworth district electric lighting provisional order.
(*b*) City of London electric lighting (Brush) provisional order.
(*c*) Islington " " " "
(*d*) Camberwell " " " "
(*e*) St. Luke's, Middlesex " " " "
(*f*) Clerkenwell " " " "
(*g*) Westminster " " " "
(*h*) Woolwich " " " "
(*i*) Hackney " " " "
(*j*) Chelsea " " " "

The board asked that any observations which the council wished to offer should be sent in at the earliest possible moment. We have accordingly taken these orders into consideration, and under the authority of the resolution of the council above referred to, have suggested to the Board of Trade that the following amendments should be made in them—

Wandsworth, Islington, Camberwell, St. Luke's, Middlesex, Clerkenwell, Woolwich, Hackney and Chelsea Orders.—That the duty of appointing auditors be left with the Board of Trade; that the regulation with reference to overhead wires, contained in clauses 10 and 83 of the Wandsworth order and corresponding clauses of the other orders, be recast so as to correspond with the form of clause in the orders of 1890; that the guarantee period for consumers be reduced from three years to two; that the definitions of the duties of inspectors, be, as in the orders of 1890, entirely left in the hands of the council or the Board of Trade according as the inspectors are appointed by one or the other; that the supplying of maps and plans of the authorised areas be made obligatory on the undertakers; that the purchase clauses be made to run from the 26th of August, 1889, and not from the date of the passing of the Acts confirming the orders; verbal and minor amendments.

City of London (Brush) Order.—The suggested amendments in this case are confined to unimportant alterations of detail.

Westminster Order.—The only amendment, other than verbal, we had to suggest in this order was that the council's bridges should be excluded from the area.

We recommend that the course taken by us with reference to the above-mentioned electric light provisional orders be approved.

Subways.

We have considered an application by the superintending engineer, Post Office Telegraphs Department, for permission to suspend an additional cable in the Victoria Embankment subway to the existing line of pipes between New Bridge Street and Charing Cross; to lay a line of 3-inch pipes across the carriageway opposite the south end of Craven Street, and to take one end of the pipes into the subway; and to connect the end of an additional line of 3-inch pipes with the subway at New Bridge Street. There appears to be no objection to what is proposed; and we recommend that the sanction of the council be given to the execution by the Post Office Telegraphs Department of the works above specified, upon condition that all the works shall be

carried out, and that any damage that may be done to the subways or to the carriageway of the Victoria Embankment in their execution shall be made good, under the supervision and to the satisfaction of the council's chief engineer, and at the sole cost of the Post Office Telegraphs Department.

We have considered an application from the Exchange Telegraph Company, for permission to lead a wire from the existing cable in the subway of Shaftesbury Avenue into the Lyric wine bar, No. 8 in that thoroughfare. We see no objection to what is proposed; and we recommend that the required permission be given to the Exchange Telegraph Company, to make the connection referred to in the application, upon condition that the work shall be carried out, and that any damage that may be done to the subway in the execution of the work shall be made good, under the supervision and to the satisfaction of the council's chief engineer, and at the sole cost of the company.

NOTICES UNDER ELECTRIC LIGHTING ORDERS AND ACTS.

We have considered notices from the Westminster Electric Supply Corporation as follows:—

20th March, 1891, of intention to lay mains in Norfolk Street and Wood's Mews.

26th March, 1891, of intention to lay mains in Park Street, Aldford Street, South Street, Farm Street, Deanery Street, and John Street.

26th March, 1891, of intention to lay mains in Market Street, Chapel Street, East, Little Stanhope Street, Shepherd Street and market, Carrington Street and Whitehorse Street.

26th March, 1891, of intention to lay mains in Gilbert Street, Thomas Street, South Moulton Street, Sedley Place, Woodstock Street, Blenheim Street, and Dering Street.

26th March, 1891, of intention to lay mains in Mill Street.

4th April, 1891, of intention to lay mains in Lees Mews and Shepherd's Court.

The proposed works are similar to those sanctioned by the council on previous notices of this company; and we recommend that the sanction of the council be given to the works referred to in the six notices of the Westminster Electric Supply Corporation, one dated 20th March, three dated 26th March, and one dated 4th April, 1891, upon condition that the company do give two days' notice to the council's chief engineer before commencing the work in any of the streets specified in the notices; that the mains be laid under the footways wherever it is found practicable to do so; and that the covers of the boxes to be used shall consist of iron frames filled in with material to suit the paving.

The same company has asked sanction to the mains for Grosvenor Crescent being laid on the north side of the thoroughfare, instead of on the south side as shown upon the plan approved by the council on the 1st April last year. We see no objection to the proposed alteration; and we recommend that the council do sanction the laying of the Westminster Electric Supply Corporation's mains on the south side of Grosvenor Crescent instead of on the north side as previously approved.

We have also considered notices from the Kensington and Knightsbridge Electric Lighting Company, dated 23rd March and 1st April, 1891, respectively, of proposed extensions of mains in Park Place, and in Chapel Place. The proposed works are unobjectionable; and we recommend that the sanction of the council be given to the works referred to in the notices, dated 23rd March and 1st April, 1891, respectively, of the Kensington and Knightsbridge Electric Lighting Company.

The London Electric Supply Corporation has served notices as follows:—26th March, 1891, of intention to lay distributing mains in St. Martin's Lane and Court, Peter's Court, Cecil Court, Cranbourne Street, Great Newport Street, Charing Cross Road, Bear Street, Leicester Square, and Hunt's Court. 6th April, 1891, of intention to lay distributing mains in Great and Little Queen Streets, Queen Anne's Gate, Broadway, Great Chapel Street, Tothill Street, Broad Sanctuary, and Little George Street. 6th April, 1891, of intention to lay distributing mains in Duke Street and Piccadilly.

These works are of the usual character, and we see no objection to them. We recommend (*a*) That the sanction of the council be given to the works referred to in the notices of the London Electric Supply Corporation, one dated 26th March, and two dated 6th April, 1891, upon condition that the company do give two days' notice to the council's chief engineer before commencing the works in any of the specified streets; that the mains for Charing Cross Road be laid and properly protected in the subway there; that the positions to be occupied by the mains in the subway be subject to the approval of the chief engineer of the council, and that the work of placing them be carried out to his satisfaction; that the mains in the other thoroughfares specified in the notices be laid under the footways, and be kept 9 inches below the under side of the paving wherever it is found practicable to do so; that where the mains cross the carriageways they be kept at the same depth below the concrete or the road material as the case may be; and that as an additional precaution against accident through defective insulation of the mains, each of the street boxes shall be provided with an inner as well as an outer cover, each insulated from the other as far as practicable, and that the outer cover shall be efficiently connected to earth. (*b*) That the clerk be instructed to forward to the company a notice requiring it to lay the mains for Charing Cross Road, referred to in the notice dated 26th March, 1891, in the subway of that thoroughfare.

We have also considered a further notice from the same company, dated 26th of March, 1891, of intention to lay distributing mains in New and Old Bond Streets. This notice is for a system of low tension mains with transformers; but the particulars supplied by the company are insufficient, and until further information, which has been asked for, shall have been received, the council's chief engineer will be unable to report upon the proposed works. In these circumstances we recommend that the council do formally disapprove the works referred to in the notice dated 26th March, 1891, of the London Electric Supply Corporation.

We have also to report the receipt of the undermentioned notices, given in accordance with the resolution of the council to accept four days' (instead of one month's) notice in respect of the laying of service lines from mains already laid:—

From the London Electric Supply Corporation—

19th March, 1891—To 12 and 39, Park Lane, and 27 and 29, Norfolk Street.
19th " " —To 57 and 64, Grosvenor Street.
19th " " —To 117, 118, 125, 126, and 127, Piccadilly.
19th " " —To 24, Grosvenor Square.
19th " " —To 98, Piccadilly, and 24, Grosvenor Street.
20th " " —To 3, Grosvenor Square.
23rd " " —To 41 and 43, Brook Street, 90, Piccadilly, and 16, Davies Street.
26th " " —To 24 and 64, Grosvenor Street, and 5, Half-Moon Street.
26th " " —To 1, Upper Brook Street, and 23, Grosvenor Square.
26th " " —To 6, Clarges Street, 3, Grosvenor Street, and 72, South Audley Street.
28th " " —To 38, Berkeley Square.
2nd April " —To 19, Grosvenor Square.
4th " " —To 35, Grosvenor Street.

From the Electricity Supply Corporation—

31st March, 1891—To Charing Cross Hotel.

The Electricity Supply Corporation having applied for sanction to an enlargement of the street-box in the footway at the corner of Bedford Street, by means of which two boxes in the carriage way of the Strand already sanctioned will be rendered unnecessary, we have, in order that the work might not be delayed, given the required sanction to the alteration. We recommend that the course taken by us be approved.

The Notting Hill Electric Lighting Company has given a notice, dated 7th April, 1891, of proposed extension of mains in Pembridge Crescent, Holland Park, and Linden Gardens. The proposed works are unobjectionable, and we recommend that the sanction of the council be given to the works referred to in the notice, dated 7th April, 1891, of the Notting Hill Electric Lighting Company, upon condition that the company do give two days' notice to the council's chief engineer before commencing the work; that the cover-stones of the culvert shall be not less than 2 inches thick; and that where the culvert crosses the car-way, there shall be at least 9 inches thickness of Portland cement concrete above the cover-stones of the culvert in addition to the road material.

The same company has called attention to the fact that its supply is by low-tension direct current, and has asked that the requirement attached to the council's sanction, given on 24th March last, to the works referred to in company's notice, dated 12th March, 1891, that each of the street boxes shall be supplied with an inner as well as an outer cover, may be withdrawn, and that the boxes may be of the pattern previously approved by the council. As this company's is a low tension system of supply, there is no reason for requiring the additional precaution; and we recommend that the Notting Hill Electric Lighting Company be informed that the council will not insist upon compliance with the requirement attached to its consent to the works referred to in the company's notice, that each of the street boxes should be provided with a second cover, and that boxes of the pattern previously approved may be used.

The Metropolitan Electric Supply Company has given a notice, dated 19th March, 1891, of intention to lay two service lines in the Strand and Exeter Street. There appears to be no objection to these works; and we recommend that the sanction of the council be given to the works referred to in the notice of the Metropolitan Electric Supply Company, dated 19th March, 1891, upon condition that the company do give two days' notice to the council's chief engineer before commencing the works; that the mains be inclosed in iron pipe or efficient casing, and be laid under the footways wherever it is found practicable to do so; that, as an additional precaution against accident through defective insulation of the mains, each of the street boxes shall be provided with an inner as well as an outer cover insulated from each other as far as practicable, and that the outer cover, which shall consist of an iron frame filled in with material to suit the paving, shall be efficiently connected to earth.

We have considered a letter from the London Electric Supply Corporation, stating that it is frequently found necessary to lay mains of a different size and description to those specified in the company's notices to the council; and asking that a general description may be accepted for all sizes of mains, notice being afterwards given of the sectional area to be occupied when it shall have been finally decided which size of main is to be laid. We see no objection to the request of the company being complied with, provided that the company do give in each case sufficient notice as to the size of the main to be used, and that in all cases a general description of the main be sent with the first notice. We recommend that the London Electric Supply Corporation be informed to this effect.

ELECTRIC TESTING STATION.

We have to report that, it being necessary for the purpose of testing electric meters to obtain a supply of current to the electric testing station from the Metropolitan Electric Supply Company, we have given instructions for arrangements being made for such supply, and for the necessary fittings to be obtained at a cost not exceeding £40.

ELECTRIC LIGHTING—STANDARD MEASUREMENTS.

We have considered a letter from the secretary of the Electrical Standards Committee of the Board of Trade, inviting the Council to suggest the names of one or two gentlemen to give evidence with reference to the adoption of standard measurements. As this is a

necessary concomitant of the duty of certifying electric meters and mains, we have retained Professor Silvanus Thompson, who has acted as our adviser in connection with the equipment of the Council's electric testing station, to attend and give evidence before the committee.

PARLIAMENTARY NOTES.

ELECTRIC LIGHTING.

IN answer to Mr. S. Balfour last week,

Sir M. HICKS-BEACH said: It is not intended to grant a third provisional order under the Electric Lighting Acts in any urban district where there are already two electric lighting companies empowered by provisional orders to supply electricity, unless there are strong reasons to suppose that one of such electric lighting companies will be unable to exercise their powers within a reasonable time. Where, however, this is the case, I do not think that it is desirable that the inhabitants of a district should be entirely debarred from the advantages of competition.

TELEPHONES IN IRELAND.

In answer to Mr. Dickson on Monday night,

Mr. RAIKES said that no public demand for a telephone service between Dublin and Belfast had hitherto been communicated to the Post Office; but if the hon. member had reason to think that there was such a demand, and would communicate with him, he should be glad to give the matter his best consideration.

DELIVERY OF TELEGRAMS IN COUNTRY PLACES.

In answer to Mr. Cobb,

Mr. RAIKES said: The general question of the charges for the delivery of telegrams has been more than once considered, but I am quite prepared to have further inquiry made in view of the circumstances now existing, and I shall be glad to let the hon. member know the result in due course. He will readily understand that the inquiry will occupy some time. I should, however, say that I have considerable doubts as to the practicability of establishing a general rural delivery of telegrams at the rates suggested in the question.

LEGAL.

Savory and Moore v. The London Electric Supply Corporation, Limited.—This was an action which came before Mr. Justice Kekewich in the Chancery Division of the High Court of Justice on Tuesday and Wednesday, in the shape of an application by the plaintiffs, who are chemists of Bond Street, for an injunction to restrain the defendant corporation from so carrying on their business as to be a nuisance—the nuisance consisting of the danger from fire to the plaintiffs' premises, where a large quantitity of inflammable drugs and other goods were stored, in consequence of the high-pressure system of transmitting electricity used by the defendants, amounting sometimes to as much as 10,000 volts.

Mr. C. M. Warmington, Q.C., and Mr. Vernon Smith were counsel for the plaintiffs, while Mr. Fletcher Moulton, Q.C., and Mr. Hamilton represented the defendant corporation.

The plaintiffs' case, in support of which considerable evidence was called, was that, in consequence of the use of the high-pressure system there was great danger from fire from the defendants' distributing centre in Grosvenor Mews, where they received large supplies of electricity, sent to them from their generating station at Deptford. It was stated that a number of accidents had already occurred at the Bond Street works, and that there had been, at least, one serious fire on the defendants' premises. The London Electric Supply retorted that when the accidents and fire occurred their Bond Street property was only temporarily fitted up, but that now the chamber in which the electricity was received at high pressure and converted to a lower pressure for ordinary domestic use was made entirely fireproof, so that under no circumstances could a fire occur again, as there was nothing combustible in the room.

His Lordship, in the result, directed the action to stand over for three months, with a view to seeing whether the defendant corporation would take extra precautions to prevent any danger from fire, or otherwise, arising from the use of the upper portions of their building into which electrical appliances might be introduced. He was not satisfied that the upper floors were fireproof, but thought the defendants should have proper time to render them so.

Jablochkoff's Patent (Electric Light).—This was a petition of the Electrical Engineering Corporation, Limited, presented to the Judicial Committee of the Privy Council for the prolongation of letters patent, dated May 22nd, 1877, granted to Mr. Paul Jablochkoff for the invention of "a new process of producing and dividing electric light, and apparatus therefor."

Mr. Moulton, Q.C., and Mr. Roger Wallace were counsel for the petitioners; Mr. Henry Sutton for the Crown.

Mr. MOULTON said he was obliged to put before their Lordships a difficulty in his way which his clients had only learned within the last few days—namely, that the opponents were going to bring before the Judicial Committee a certain prior publication which they alleged anticipated his clients' patent—viz., a paper read at a meeting of the Society of Telegraph Engineers on May 9th, 1877. The paper was communicated by some unknown person, and without Mr. Jablochkoff having anything to do with it. Consequently, he was obliged to admit that that prior publication rendered the patent invalid unless there could be a confirmation under the powers of the statute 5 and 6 William IV., c. 83, sec. 2. He asked their Lordships to allow him to amend the petition by adding a prayer for confirmation, or he invited them to prolong the patent on the present petition, he undertaking that, until confirmation, no claims should be made thereunder.

After some discussion, their LORDSHIPS suggested that the matter should stand over for a time, so that Mr. Moulton's clients might consider what steps they should take as to filing a fresh petition.

Mr. MOULTON acceded to this course, and the matter was accordingly adjourned.

B. Verity and Sons v. Terry.—This case came before Mr. Justice Charles on Monday. The plaintiffs sued Mr. Edward O'Connor Terry, the actor and proprietor of Terry's Theatre, to recover £593, for work done at defendant's theatre. The defendant had paid the plaintiffs £120 and now paid £27 odd into court, but disputed his liability as to the remainder. Mr. Moulton, Q.C., and Mr. Buckmaster appeared for the plaintiffs; while Mr. Cyril Dodd, Q.C., and Mr. Bullen represented the defendant. It appeared that in January, 1890, Mr. Terry, the defendant, who was going to India, let his theatre to Miss Graham. Some question arose about the electric lighting, and defendant said that, although he was not bound under his contract to alter the system, he would see what could be done. The plaintiffs submitted an estimate of the cost of alterations, which they placed at about £100. On commencing the work, however, it was found that a great deal more work was wanted than had been anticipated; and, according to the plaintiffs' case, at the request of defendant's manager, work to the extent of the claim was done. The defendant's case, however, was that the gentleman in question did not give the orders, and even if he did he had no authority from defendant to do so, as he had ceased to be his manager and had become manager for Miss Graham, who paid him. Singularly enough, the title of the play running about this time was *New Lamps for Old*. Ultimately the parties left it to his Lordship to say what was fair between them, and the learned Judge in deciding the case said it was an unfortunate one. Mr. Terry on his return to England had a larger bill presented to him than he anticipated. But the work done by the plaintiffs was excellent and the prices reasonable, and Mr. Terry did not want to enjoy the improvement for nothing. He thought, under the circumstances, the best course would be to give judgment for the plaintiffs for £375, including the sums paid to the plaintiffs and into court. Judgment accordingly.

NOTES.

To our London Readers.—The offices of the ELECTRICAL REVIEW are again connected with the National Telephone Company's Exchange, the call number being 517.

Electric Lighting at Southampton.—At a meeting of the Town Council last week a motion was brought forward to the effect that immediate steps should be taken to enforce the repaving of the High Street, and in the event of refusal or any further delay on the part of the contractors legal steps should be taken to recover the penalties for such delay under the 10th section of the Electric Lighting Act. The secretary of the Electric Light Company said that they desired to avoid anything to cause unnecessary inconvenience to the public. Through an unforeseen accident the work had been temporarily delayed, but the contractors would now push on with the work as expeditiously as possible. The motion was withdrawn.

The Lauffen-Frankfort Power Transmission Scheme.—The *Elektrotechnische Zeitschrift* states that the firm of F. A. Hesse Söhne, of Heddernheim, have offered to provide on moderate terms the copper wires for the transmission of 300 H.P. from Lauffen to Frankfort. The total length of conductor required is about 310 miles. It is believed now that the difficulty of obtaining the wires has been overcome, and the project will be carried out.

Electric Lighting of Antwerp.—The differences which have existed for years with the gas company have now been overcome, and the work of lighting the town by electricity will shortly be commenced. A few years ago preparations were made for this purpose. The erection of a central station was begun, and cables were actually laid in the streets; but when the General Electricity Company wished to start the lighting, the gas company sought and obtained an injunction.

Electric Light Installations.—Sir David Salomons's work, "Electric Light Installations and the Management of Accumulators," has been translated into French by M. P. Clémencean. It is entitled "Les Accumulateurs Electriques: Leur Emploi dans les installations d'eclairage prixé," and is sold at less than half the price of the English edition!

The "Engineering Review."—Under the title of the *Engineering Review*, the first number will be published early in May of a new monthly journal for civil, mechanical and electrical engineers. It is intended to make the journal of a high class character. The proprietors and publishers are Messrs. Andrée and Walker, St. Paul's Chambers, 19, Ludgate Hill, E.C.

Institution of Electrical Engineers' Students.—A general meeting of the students was held on Friday, 10th, when a paper was read by Messrs. Matthews and Seaman on "Photometry," some apparatus being kindly lent by Messrs. Alex. Wright and Co., Westminster. The next meeting will be held on the 24th inst., when a paper will be read on "Alternate Current Motors," by Mr. G. U. Yule.

Berly's Electrical Directory.—The tenth annual publication of this directory is now out, the date of the preface (January, 1891) showing that it is later in making its appearance than was intended. The whole contents of the book have been thoroughly revised, and it is increased in size by 180 pages as compared with the previous year. Special attention has been given to the continental section, which is fuller in its details and more copious in its information than any previous issue, and is believed to be as accurate as it is possible to make it. As a whole the directory is considerably improved, and deserves more than ever its sub-title of the electrician's *vade mecum*.

The National Telephone Electrical Society.—Last Friday Mr. W. Johnstone, Inspector-in-Charge at Kidderminster, and late Secretary of the Society, read a paper on "Some forms of Switchboards for Small Exchanges," Mr. A. E. Cotterell, vice-president and district manager of the company, in the chair. Mr. Johnstone treated upon the various systems in use in different countries, and in different parts of the country. A discussion followed, chiefly upon the advantages and disadvantages of the call-wire system. The paper was very much appreciated, and very heartily applauded.

The Electric Light at Exeter.—At a meeting of the Town Council last week the Parliamentary Committee reported that the Electric Light Company had intimated that although the directors could not consent to the proposal of the council that the option of purchase should arise at the end of 25 and 32 years, they were willing, for the sake of disposing of the matter, to leave it to the Board of Trade to decide between the parties whether the option should arise at the end of 25 and 32, as contended for by the council, or at the end of 28 and 35, as proposed by the company. The report was adopted, and satisfaction expressed that the question at issue between the council and the company had been almost brought to a satisfactory conclusion.

The Electric Light at Bournemouth.—At a meeting of the Town Council last week, the Lighting Committee reported the receipt of a letter from the Board of Trade, enclosing a copy of a letter from the Brush Electrical Engineering Company, in which the company expressed their wish to form a local company at Bournemouth, and to transfer to it the orders granted to them, and asking for the observations of the council upon the proposal. The committee recommended that the clerk reply to the effect that until the council were furnished with more particulars as to the proposed new company they were not in a position to give a reply. They also recommended that a letter be sent to the Brush Electrical Engineering Company, asking them to furnish the council with full particulars as to the proposed new company. The report was adopted.

Electric Lighting at Studley Royal.—The famous residence of the Marquis of Ripon is to be partially lighted by electricity.

The Royal Society.—The following paper by Prof. Hartley, F.R.S., was down for reading yesterday:—"The Physical Characters of the Lines in the Spark Spectra of the Elements."

New Electric Bell.—The Birmingham Telegraph Factory, Limited, are sending out a newly-designed bell, the base and cover of which are of decorated porcelain, the frame of iron, japanned to harmonise with the colour of the porcelain, the brass parts lacquered in rich gold, and the gong silver plated. As regards shape, design and material, it is a distinct advance on anything yet attempted in this way.

Edlin and Stevenson.—Mr. A. D. Stevenson, late manager to Messrs. Drake and Gorham, whose contemplated departure for South Africa was referred to in our issue of 3rd inst., is now on his way out. His intention is to join in partnership Mr. H. W. Edlin, M.I.M.E., who preceded him by about 12 months, and to establish a general electrical contract business. The style of the firm will be Edlin and Stevenson, and their address 36, Church Street, Cape Town.

The Institution of Electrical Engineers.—At the ordinary general meeting last night the continuation of the discussion on Mr. W. B. Esson's paper, "The Design of Multipolar Dynamos," was announced.

On Thursday, April 23rd, 1891, the following papers will be read:—1. "On some Effects of Alternating Current Flow in Conductors having Capacity and Self-Induction," by Dr. J. A. Fleming, Member; 2. "A Few Calculations on Electrical Shocks from Contact with High-pressure Conductors," by Major P. Cardew, R.E., Member.

Personal.—We are informed by Messrs. Cathcart and Peto that they have taken into partnership Mr. F. W. A. Radford, and that the title of the firm will in future be Cathcart, Peto and Radford. They intend shortly to considerably increase their premises at 57B, Hatton Garden, E.C.

A Compensation Case.—Mr. John Brennan, the Under Sheriff of Kent, and a special jury are considering the claims of the Rochester Electric Light Company against the South Eastern Railway Company. The Electric Company were turned out of convenient leasehold premises, and they claim £15,000.

Leeds Corporation and the Electric Light.—At the meeting of the Town Council to-day, the Parliamentary Committee will recommend the Council to permit the House-to-House Company to apply for a provisional Order.

Mutual Telephone Company.—We have received copies of a number of testimonials from subscribers to the Mutual Telephone Exchange in Manchester, which bring out conspicuously the superiority of the Mutual Company's system. Satisfaction is expressed at the absence of induction and cross-talk on the subscribers' lines. The privacy of conversation and the time saved in ringing up is also appreciated.

Varley's Original Dynamo.—Mr. J. P. Barrett, electrician to the "World's Fair," has received an offer from Mr. S. A. Varley, in which he expresses willingness to go to America and exhibit his original dynamo at the forthcoming exhibition. The committee have the matter under consideration.

Electrical Convention and Exhibition.—An electrical convention is to be held at Montreal in August. In connection therewith there will be an exhibition of apparatus made by Canadian and American electrical engineers.

The First Cable Made in France.—The first submarine cable of French manufacture is now being finished at the new works of the Société des Téléphones at Calais.

Woodhouse and Rawson.—In view of the large number of orders in hand for steam and electric launches, tugs, &c., together with others promised and in course of negotiation, Messrs. Woodhouse and Rawson United, Limited, have resolved to extend their riverside premises, and have, therefare, just purchased a piece of ground situated close to Kew Railway Bridge, on the Surrey side, with a frontage to the river of between 600 and 700 feet, the total area being about 2½ acres. For the buildings, plant, and machinery, arrangements have already been made, and the company will also have good dock accommodation in connection with the above, where tugs and barges can safely lie while undergoing any necessary repairs and alterations. The new works, which are nearly opposite the two existing yards of the company, are expected to be in working order in the course of the next two months.

NEW COMPANIES REGISTERED.

The International Electric Syndicate, Limited.—Capital £12,000 in £10 shares. Objects: to acquire and hold the rights granted by letters patent under the Great Seal of the United Kingdom, to J. Elsner, numbered respectively 13,459 dated August 27th, 1889, Brevets d'Invention, France, No. 200,457 dated August 31st, 1889, November 18th, 1889, Belgium, No. 87,889 dated September 30th, 1889, October 15th, 1889, United States, No. 334,799 dated December 23rd, 1889, granted to J. F. Weyde, F. Clas and J. Elsner, for "Improvements in the construction of electric accumulators"; to adopt two agreements, dated 28th February last, between J. Elsner of the one part and W. H. Batts, for the company, of the other part; to buy other patents, and to sell, deal in, work and develop the said patents and others that may be acquired. Signatories (with one share each), W. D. Edwards, Commercial Sale Rooms, Mincing Lane, E.C.: G. L. Russell, Monks Risboro', Bucks; A. Foglar, 40, Alma Square, St. John's Wood, N.W.; R. W. Davey, 7, Mincing Lane, E.C.; H. V. Tyrrel, 22, Claremont Square, N.; T. H. Deakin, Parkend, Gloucester; J. A. Elsner, 38, Cressillian Road, S.E. Registered without special articles on the 10th inst, by S. James, solicitor for the company, 60, Lincoln's Inn Fields, W.C. Registered office, 5, Guardian Buildings, Manchester.

The New York City Freehold Estates Corporation, Limited.—Capital, £471,000 divided into 80,000 ordinary and 14,200 founders' shares of £5 each. Objects: to adopt an agreement with the States Property Syndicate, Limited, mentioned in clause 3 of the articles, to acquire other land in New York, to erect dwelling houses and other buildings and to acquire, construct, hire, equip and work roads, bridges, railways, tramways, mills, vessels, telegraph lines, telephones, works and plant of every description. Signatories (with one share each), L. Ashley, Audley Mansions, South Audley Street, S.W.; Major-General Lloyd, 8, Mapesbury Road, N.W.; G. H. Hopkinson, 3, Regent Street, W.; D. G. Sandeman, 94, Piccadilly, W.; W. Strapp, Ladbroke, Red Hill; R. D. Baxter, 12, Victoria St., S.W.; R. Liepmann, 40, Lexham Gardens, London. The number of directors is not to be less than 3 nor more than 9, the first to be appointed by a majority of the subscribers. Qualification, £500. Remuneration, £250 each per annum and £100 in addition for the chairman. Registered on the 10th inst., by Ashurst, Morris, Crisp & Co., solicitors to the company, 17, Throgmorton Avenue, E.C.

The Brill Brick and Tile Company, Limited.—Capital, £10,000 in £5 shares. Objects: to carry on the business of brick, tile, terra-cotta and cement manufacturers and agents; to search for, make merchantable and dispose of brick-earth, chalk, lime, whiting, pottery and other goods; and to produce and use electricity, magnetism, or other power. Signatories (with one share each), R. A. Jones, Brill, Buckingham; W. J. Bond, Brill, Buckingham; M. W. Stevens, Brill; H. Puddefoot, Waddesden; H. H. Sherwin, Waddesden; G. A. Sims, Waddesden; and C. Walton, 12, Craven Street, W.C. The number of directors, unless otherwise determined by a resolution of a general meeting, is not to be less than 3 nor more than 5, the first being W. J. Bond, H. H. Sherwin and R. A. Jones. Qualification, 10 shares. Remuneration (except that of managing director), £50 per annum each. Registered on the 11th inst., by Young, Jones & Co., 2, St. Mildred's Court, Poultry, E.C. Registered office, Brill, Buckingham.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

The Manchester House-to-House Electricity Company, Limited.—The statutory return of this company made up to the 4th December, 1889, was filed on the 31st ult. The nominal capital is £100,000 divided into 19,900 ordinary and 100 founders' shares of £5 each. 7 shares have been taken up, but upon these no call has been made. Office: 15, St. Helen's Place, E.C.

The Scottish House-to-House Electricity Company, Limited.—The annual return of this company, made up to 13th January last, was filed on the 31st ult. The nominal capital is £100,000 divided into 19,900 ordinary and 100 founders' shares of £5 each. 7 shares have been taken up, but upon these no call has been made. Office: 15, St. Helen's Place, E.C.

The Mexican Gas and Electric Light Company, Limited.—The annual returns of this company, made up to the 19th December, 1889, and to the 19th December, 1890, were filed on the 24th ult. The nominal capital is £100,000, in £20 shares. In both of these returns, 5,000 shares have been taken up, upon none of which has anything been called. The total amount considered as paid is equal to the nominal capital—£100,000. Office: 15, Bishopsgate Street Within, E.C.

The Midland House-to-House Electricity Company, Limited.—The annual return of this company, made up to the 13th January last, was filed on the 31st ult. The nominal capital is £100,000, divided into 19,900 ordinary and 100 founders' shares of £5 each. 7 shares have been taken up, but upon these no call has been made. Office: Bennett's Hill, Birmingham.

The Northern House-to-House Electricity Company, Limited.—The annual return of this company, made up to the 13th January last, was filed on the 31st ult. The nominal capital is £100,000, divided into 19,900 ordinary and 100 founders' shares of £5 each. 7 shares have been taken up, but upon these no call has been made. Office: 21, Grainger Street West, Newcastle-upon-Tyne.

The Birmingham House-to-House Electricity Company, Limited.—The annual return of this company, made up to the 13th January last, was filed on the 31st ult. The nominal capital is £100,000, divided into 19,900 ordinary and 100 founders' shares of £5 each. 7 shares have been taken up, but upon these no call has been made. Office: Bennett's Hill, Birmingham.

The Electricity Supply Company for Spain, Limited.—The annual return of this company, made up to the 7th January last, was filed on the 31st ult. The nominal capital is £100,000, divided into 19,900 ordinary and 100 founders' shares of £5 each. The whole of the shares have been taken up, upon 19,900 of which the full amount has been called. The calls paid amount to £99,470; considered as paid, to £500; and unpaid to £30. Office: 15, St. Helen's Place, Bishopsgate Street, E.C.

The Electrical Engineering Corporation, Limited.—The first annual return of this corporation, made up to the 12th ult., was filed on the 24th ult. The nominal capital is £150,000, divided into 29,600 ordinary and 400 founders' shares of £5 each. 11,272 ordinary and 24 founders' shares are taken up, and upon 1,922 ordinary and 24 founders' shares the full amount has been called. 9,350 ordinary shares have been considered as paid. The calls paid amount to £9,710; considered as paid, to £46,750; and unpaid, to £30. Office: 3, Princes Mansions, Victoria Street, Westminster, S.W.

The London Electric Supply Corporation, Limited.—The annual return of this company, made up to the 27th ult., was filed on the 3rd inst. The nominal capital is £1,250,000,

divided into 200,000 ordinary and 50,000 preference shares of £5 each. 111,000 ordinary and 50,000 preference shares are taken up, and upon all of the ordinary shares the full amount has been called. Upon 16,251 preference shares the full amount has been called, and upon the remainder of the preference shares £3 per share has been called. The calls paid amount to £726,205, and unpaid to £11,297. Office: 3, Adelphi Terrace, Strand, W.C.

The Wolverhampton Electric Light and Power Company, Limited.—The annual return of this company, made up to the 31st December last, was filed on the 26th ult. The nominal capital is £50,000 in £10 shares. 23 shares are taken up, upon all of which the full amount has been called and paid. Office: Lichfield Street, Wolverhampton.

The Yorkshire House-to-House Electricity Company, Limited.—The annual return of this company, made up to the 13th January last, was filed on the 31st ult. The nominal capital is £100,000 divided into 19,900 ordinary and 100 founders' shares of £5 each. 7 shares have been taken up, but upon these no call has been made. On the 9th inst., the notice of a change in the registered office was filed. It is now situated at 32, Park Row, Leeds.

The South of England House-to-House Electricity Company, Limited.—The annual return of this company, made up to the 13th January last, was filed on the 31st ult. The nominal capital is £100,000 divided into 19,900 ordinary and 100 founders' shares of £5 each. 7 shares have been taken up, but upon these no call has been made. Office: 15, St. Helen's Place, E.C.

Macmahon's Patent Electric Check System, Limited.—The registered office of this company was on the 25th ult. changed to 24, Great Windmill Street, Piccadilly, W.

CITY NOTES.

The Indo-European Telegraph Company, Limited.

THE directors, in their report for 1890, have to regret the death of one of the foreign members of the board, Mr. A. Delbrück, banker, of Berlin.

The company's revenue from all sources for 1890 amounted to £113,807 3s. 11d., as compared with £108,288 15s. 5d. for 1889, showing an increase of £5,518 8s. 6d.

The expenses were: On commercial and general account £29,728 18s. 1d.; on maintenance account, £28,173 1s. 6d.; total, £57,901 19s. 7d., as against £59,240 6s. 9d. for 1889, a decrease of £1,338 7s. 2d.

Deducting the above expenses, taking credit for £2,035 10s. 3d. brought over from 1889, and debiting income tax, there remains the sum of £56,668 16s. 7d.

From this amount £10,000 has been placed to reserve, and that sum, together with £10,625 amount of interim dividend, has to be deducted, leaving a balance of £36,043 16s. 7d.

The directors now propose the declaration of a dividend for the six months ending December 31st, of 17s. 6d. per share, making, with the dividend already paid, 6 per cent. for the year and a bonus of 20s. per share, both free of income tax, making in all 10 per cent., carrying forward £4,168 16s. 7d. to the credit of 1891.

As the shareholders are aware, the Telegraph Conference was held last year in Paris. Nothing occurred to materially affect the interests of the company.

The directors, in association with some of the Australian colonies and the Eastern Extension Telegraph Company, as well as the Indian Government and the Eastern Telegraph Company, subject to the consent of certain Governments interested, have arranged as an experiment to introduce a 4s. per word rate, for messages exchanged with the Australian colonies. This is made practicable owing to the guarantee of the colonies to bear half of the loss sustained by the application of the reduced rates.

Queensland and New Zealand, which have declined to join in the above guarantee, will not participate in the benefit of the reduction.

Should the trial thus proposed to be given to very low rates prove a failure, the tariffs will be again raised.

Duplex apparatus have been applied and are working very satisfactorily upon both of the company's land and cable wires between London and Germany.

It will be observed that notice is given of a special resolution which the board consider advisable in the interests of the company.

The following directors retire by rotation, and offer themselves for re-election:—J. Herbert Tritton, Esq., and Major-General Tremenheere, R.E.

In case any shareholder should be unable to attend the general meeting, he is requested to fill up and return the enclosed proxy form, duly signed, so as to reach the company's office not later than noon of the 25th inst.

Holders of shares to bearer must deposit their shares, with name and address, at the office of the company, 48 hours before the time appointed for the meeting, against an order for admission.

The share warrants will be returned after the meeting.

The transfer books will be closed from the 14th to the 28th instants, both inclusive.

REVENUE ACCOUNT, 1890.

Dr.	£	s.	d.
To Salaries and wages	16,811	15	0
„ Direction and audit	2,755	0	0
„ Rent	1,547	18	11
„ Stations expenses	1,771	3	2
„ Stationery	1,067	13	9
„ Medical attendance	200	0	0
„ Postages and stamps	258	10	9
„ Carriage and freight	164	3	9
„ Law charges	127	10	0
„ Travelling expenses	521	8	6
„ Agency and general expenses	3,617	5	9
„ Insurance and endowment fund	629	13	1
„ Expenses of the International Telegraph Conference at Paris	256	15	5
„ Maintenance— Expenses incurred by the company to 31st December	28,173	1	6
	57,901	19	7
„ Balance carried to profit and loss account... ...	55,905	4	4
	£113,807	3	11

Cr.	£	s.	d.
By Receipts (less outpayments and wire rentals) ...	113,739	1	7
„ Interest on accounts less loss on exchange ...	59	4	10
„ Transfer fees	8	17	6
	£113,807	3	11

PROFIT AND LOSS ACCOUNT, 1890.

Dr.	£	s.	d.
To Interim dividend declared and paid for the half-year ended 30th June, 1890, at the rate of 5 per cent. per annum, free of income tax ...	10,625	0	0
„ Amount placed to reserve fund for 1890	10,000	0	0
„ Balance	36,043	16	7
	£56,668	16	7

Cr.	£	s.	d.	£	s.	d.
By Balance from 1889				2,035	10	3
„ Balance from revenue, 1890 ...	55,905	4	4			
Less income tax paid	1,271	18	0			
				54,633	6	4
				£56,668	16	7

Dr.	£	s.	d.
To Proposed dividend of 17s. 6d. per share, making with the interim dividend already paid a total distribution for the year 1890 of 6 per cent. per annum, free of income tax	14,875	0	0
„ Proposed bonus of 20s. per share	17,000	0	0
„ Balance proposed to be carried forward to 1891 ...	4,168	16	7
	£36,043	16	7

Cr.	£	s.	d.
By Balance down	36,043	16	7
	£36,043	16	7

SUSPENSE ACCOUNT, 1890.

Dr.	£	s.	d.
To balance of items paid towards the liquidation of the Persian debt of 1870, 1871, 1872, 1873, 1882 and 1883, being in the nature of a reserve fund	9,930	7	4
Less instalment deducted from the royalty payable to Persia for 1890, and transferred to reserve fund ...	1,986	1	4
	£7,944	6	0

Cr.	£	s.	d.
By Persian Government for balance of amounts paid towards the liquidation of the Persian debt (repayable out of deductions from the royalty as described in the directors' report for 1870)	7,944	6	0
	£7,944	6	0

BALANCE SHEET, 31st December, 1890.

DR.	£	s.	d.	£	s.	d.
To Share capital—						
18,000 shares at £25 each ...	450,000	0	0			
Less unissued—						
1,000 shares at £25 each ...	25,000	0	0			
				425,000	0	0
„ Sundry creditors				26,152	12	10
„ Freehold property				1,876	0½	0
„ Reserve fund				154,790	18	5
„ Profit and loss account				36,043	16	7
				£643,863	7	10

CR.	£	s.	d.
By Construction of line	423,029	5	5
„ Freehold property	8,431	17	6
„ Sundry debtors	27,187	13	10
„ Investments on account of reserve fund (details given in original)	150,911	4	8
„ Materials for maintenance and instruments, in stock, 31st December, 1890	6,069	15	1
„ Cash at bankers on current account	2,980	11	5
„ „ „ „ deposit	25,000	0	0
„ „ at station	252	19	11
	£643,863	7	10

Great Northern Telegraph Company of Copenhagen.

WORKING ACCOUNT FOR THE YEAR 1890.

RECEIPTS.	£	s.	d.
Balance on the 31st December, 1889	46,722	5	10
Traffic receipts, less loss on Exchange (£10,605 7s. 10d.)	280,911	13	0
Interest	21,327	0	9
Sundries	6,422	3	6
	£355,383	3	1

EXPENSES.	£	s.	d.
Salaries and wages	39,686	19	1
Expenses of stations, offices and agencies	8,721	18	9
Ordinary supervision and maintenance of the sea and land lines, and repairing steamers *H. C. Oersted* and *Store Nordiske*	13,375	19	9
Instruments and cells	2,860	13	3
Maintenance of company's buildings	454	9	9
Travelling expenses	585	17	5
Bank commission, &c.	3,564	7	10
Sundries	305	10	2
Total expenses	£69,555	16	0
Five per cent. interest on debentures	12,500	0	0
Amortisation of 250 debentures...	25,000	0	0
The surplus amount is proposed to be appropriated as follows:—			
Interim dividend paid on 150,000 shares at 5 per cent.	75,000	0	0
Extra dividend of Kr. 6.50 (7/2) on 150,000 shares	54,166	13	4
Addition to the reserve and renewal fund	66,666	13	4
Addition to the pension fund of the staff	2,777	15	7
Remuneration to the board of directors	1,500	0	0
Balance carried forward	48,216	4	10
	£355,383	3	1

BALANCE OF THE COMPANY 31ST DECEMBER, 1890.

ASSETS.	£	s.	d.
Cables and land lines in Europe, China and Japan, including all appurtenances according to balance sheet, 31st December, 1889	2,048,309	6	7
New cable between England and Sweden, and paid on account of new office building at Copenhagen	86,744	10	7
Investments for account of reserve and renewal fund, &c.			
Kr. 2,000,000 3½ per cent. Royal Danish bonds	107,564	4	9
„ 1,000,000 4 per cent. Danish Railway bonds	55,555	11	1
„ 496,000 3½ per cent. bonds Danish Credit Foncier	26,453	6	8
„ 476,000 4 per cent. bonds Danish Crédit Foncier	25,717	4	5
„ 278,000 4 per cent. bonds Danish Crédit Foncier	15,637	10	0
„ 391,000 4 per cent. different bonds ...	21,830	16	8
„ 472,000 5 per cent do. do. ...	25,697	15	7
Frcs. 987,500 4 per cent, bonds Royal Swedish Mortgage Bank	36,636	5	0
„ 1,000,000 5 per cent. Royal Italian bonds	36,724	8	11
„ 997,500 3 per cent. bonds Crédit Foncier de France	26,844	7	9
„ 1,000,000 3 per cent. Rentes Françaises	32,891	4	10
„ 500,000 4 per cent. do. do. ...	21,673	8	4
£100,000 3 per cent. Norwegian bonds of 1888	89,335	16	8
Sundry shares	347	7	9
Cash in Europe, £24,220 5s. 10d.; cash in China and Japan, £817 19s. 8d.	25,038	5	6
Sundry debtors	51,619	8	3
	£2,734,620	19	4

LIABILITIES.	£	s.	d.
Share capital—150,000 shares at £10 (Kr. 180) ...	1,500,000	0	0
5 per cent. debentures 1881 and 1883—2,550 at £100 (Kr. 1,800), less amortised 250 (£25,000) ...	230,000	0	0
Amortisation account	170,000	0	0
Reserve and renewal fund, 1889	617,960	2	4
Proposed addition for 1890, less extraordinary repairs and expenses, arrears, &c. (£5,873 8s. 5d.)	66,666	13	4
Remuneration to the board of directors	1,500	0	0
Extra dividend...	54,166	13	4
Sundry creditors	51,984	13	11
Balance carried forward	48,216	4	10
	£2,734,620	19	4

The board of directors of the Great Northern Telegraph Company —Bille, Aug. Garde, V. Hoskiær, M. Melchior, E. Suenson, C. F. Tietgen, Tobiesen.

We, the undersigned auditors, have revised the above accounts, and compared the different items with the vouchers, accounts, and the company's books, and at the same time satisfied ourselves as to the presence of the above-mentioned bonds and shares, and found everything correct.

A. BERNER.
S. BILLE.

Copenhagen, *March 23rd*, 1891.

The Eastern Extension Australasia and China Telegraph Company, Limited.

THE report and accounts of the directors for the half-year ended 31st December, 1890, states that the gross receipts, including Government subsidies, have amounted during that period to £279,095 1s. against £264,103 12s. 11d. for the corresponding half-year of 1889.

The working and other expenses, including £23,118 6s. 6d. for cost of repairs to cables and expenses of ships, absorb £74,090 3s. 2d. against £73,498 19s. 3d. for the corresponding period of 1889, leaving a balance of £205,004 17s. 10d. From this is deducted £2,915 9s. 1d. for income tax, and £35,281 9s. 10d. for interest on debentures, debenture stock, and contribution to sinking fund, leaving as the net profit for the half-year £166,807 18s. 11d. Against this £1,120 19s. 6d. has been charged for cost of new land line at Banjoewangie and additions to staff quarters, and £100,000 on account of the cost of duplicating the Madras-Penang cable, which is referred to below, leaving a balance of £65,686 19s. 5d., which, with £71,820 7s. 5d. brought forward, shows an available balance of £137,507 6s. 10d.

One quarterly interim dividend of 1¼ per cent. has been paid for the half-year, and it is now proposed to distribute another of like amount, making, with the interim dividends paid for the first half-year, a total dividend of 5 per cent. It is also proposed to pay a bonus of 4s. per share, or 2 per cent., making a total distribution of 7 per cent. for the year 1890. The balance of £25,007 6s. 10d. has been carried to the general reserve fund, which, after being credited with interest and profit on sale of investments, and debited with £10,722 13s. 1d. on account of the cable renewals, &c., specified on page 6, now stands at £495,239 6s. 7d.

The directors have the satisfaction to report that, notwithstanding the financial depression existing at the time, the recent conversion of the company's 6 per cent. debentures into 4 per cent. mortgage debenture stock, was attended with marked success, the whole of the issue having been subscribed by the shareholders at par. By this operation a saving in revenue of £6,400 per annum has been effected.

Since the close of the year nearly the whole of the 6 per cent. debentures have been paid off.

In accordance with the provisions of the trust deed, dated 15th May, 1879, 320 of the company's 5 per cent. Australian Government subsidy debentures were drawn by lot on the 7th inst. for payment at par on the 1st July next. The numbers of drawn debentures are given on page 12 of this report.

The negotiations with the Governments of Australasia, referred to in the last report, have resulted in an agreement being concluded between the company and the Governments of New South Wales, Victoria, South Australia, Tasmania and Western Australia, for reduction of the tariffs to those colonies from the 1st May proximo, as follows:—From 9s. 4d. to 4s. per word for public telegrams; from 7s. 1d. to 3s. 6d. per word for Government telegrams; from 2s. 8d. to 1s. 10d. per word for Press telegrams; for a tentative period of one year, to be extended if found to work satisfactorily. The contracting colonies guarantee the company against one-half the risk of any loss should the receipts at the reduced rates fall short of the present earnings from the Australasian traffic, and the company takes the other half.

It was hoped that Queensland and New Zealand would have agreed to take part in the experiment, but after considerable negotiation between the various Governments those colonies declined to join in the guarantee; consequently the tariffs to Queensland and New Zealand will remain unchanged.

The contract with the Telegraph Construction and Maintenance Company for the manufacture and laying of the Madras-Penang duplicate cable has been satisfactorily carried out, and the service is now in a thoroughly efficient condition to meet any requirements that may arise in connection with the reduced rates to Australia.

The company's maintenance ships have, as usual, been employed on various repairs, but with the exception of the interruption of the Saigon-Tonquin cable from the 20th to the 27th October, and of the cables between Java and Australia, referred to in the last report,

there have been no interruptions materially affecting the company's revenue during the half-year under review.

In accordance with the articles of association, the Right Hon. Viscount Monck and George Garden Nicol, Esq., retire by rotation, and, being eligible, offer themselves for re-election.

REVENUE ACCOUNT for the half-year ended 31st December, 1890.

DR.	£	s.	d.
To General expenses in London ... ... (See Abstract A.)	4,978	14	10
„ Working expenses at stations ... ... (See Abstract B.)	38,515	8	10
„ Use of patents...	800	0	0
„ Electricians' retaining fee	50	0	0
„ Directors' remuneration	2,000	0	0
„ Auditors' fees	100	0	0
„ Staff endowment assurance	798	12	0
„ Expenses on account of Australian guarantee negotiations	229	1	0
„ Repairs to cables ... ... (See Abstract C.)	23,118	6	6
„ Maintenance ships reserve fund	3,500	0	0
„ Income tax	2,915	9	1
„ Interest on 6 per cent. debentures	9,600	0	0
„ Interest on sinking fund on account of 5 per cent. Australian subsidy debentures	25,495	0	0
„ Interest on 4 per cent mortgage debenture stock...	186	9	10
„ Cost of new land line at Banjoewangie	918	18	2
„ Additions to staff quarters	202	1	4
„ Part cost of the Madras-Penang duplicate cable...	100,000	0	0
„ Balance	65,686	19	5
	£279,095	1	0
„ Third interim dividend of 1890, 2s. 6d. per share, paid 15th January, 1891	31,250	0	0
„ Proposed final dividend of 2s. 6d. per share for 1890, payable 23rd April, 1891	31,250	0	0
„ Proposed bonus of 4s. per share, payable 23rd April, 1891...	50,000	0	0
„ Balance to reserve fund	25,007	6	10
	£137,507	6	10

CR.	£	s.	d.
By Message and other receipts, including profit on exchange, £257,230 14s. 8d.; less payment under agreement with Great Northern Telegraph Company, £1,250	255,980	14	8
„ Australian duplicate cable subsidies, £16,200; less deductions for 9 days total interruption, £798 18s. 1d.	15,401	1	11
„ Tasmanian cable subsidy	2,100	0	0
„ Tonquin, £5,300; less deductions for 7 days total interruption, £203 5s. 7d.	5,096	14	5
„ Malacca cable subsidy	200	0	0
„ Macao	250	0	0
„ Transfer fees	66	10	0
	£279,095	1	0
By Balance down	65,686	19	5
„ Balance of revenue account to 30th June, 1890 ...	71,820	7	5
	£137,507	6	10

BALANCE SHEET, 31st December, 1890.

DR.	£	s.	d.
To Capital— 300,000 shares of £10 each, less 50,000 unissued, £500,000	2,500,000	0	0
„ 6 per cent. debentures— 3,200 debentures of £10 each...	320,000	0	0
„ 5 per cent. Australian subsidy debentures— 4,170 debentures of £100 each, as per last account, less 305 debentures drawn 1st April, 1890, for payment 1st July, 1890, £30,500 ...	386,500	0	0
„ 4 per cent. mortgage debenture stock allotted to 31st December, 1890, £320,000, less calls since paid, £218,752 10s.	101,247	10	0
„ General reserve	495,239	6	7
„ Maintenance ships' reserve	41,871	17	3
„ Insurance reserve for maintenance ships and cables	45,749	19	5
„ Australian subsidy debenture sinking fund ...	21,515	2	0
„ Traffic and other credit balances	44,549	3	11
„ Debenture interest accrued and unpaid... ...	8,367	16	1
„ Proprietors for dividends— Unclaimed dividends	929	17	6
Third interim dividend of 2s. 6d. per share, paid 15th January, 1891	31,250	0	0
Proposed final dividend of 2s. 6s. per share, payable 23rd April, 1891	31,250	0	0
Proposed bonus of 4s. per share, payable 23rd April, 1891	50,000	0	0
	£4,078,470	12	9

CR.	£	s.	d.
By Capital expenditure as per last account, less transferred from Australian 5 per cent. subsidy debenture sinking fund, £30,500 ...	3,011,161	0	9
„ Maintenance ships, as per last account	66,449	14	10
„ Expenditure on account of Madras-Penang duplicate cable, less amount charged against the revenue account, £100,000	48,394	16	6
„ Investments on account of reserve funds ... (See Abstract D.)	507,806	2	4
„ Trustees for 5 per cent. Australian subsidy debentures...	8,220	2	0
„ Spare cable and other stores	75,357	18	2
„ Bills receivable	56,900	0	0
„ Remittances in transit	42,600	0	0
„ Traffic and other debit balances	82,666	0	11
„ Cash at bankers, on deposit, and in hand ...	178,914	17	3
	£4,078,470	12	9

Oriental Telephone Company.

THE eleventh ordinary annual general meeting of the Oriental Telephone Company, Limited, was held on Wednesday at the Cannon Street Hotel.

Mr. WILLIAM ADDISON presided, and, in moving the adoption of the report and balance-sheet, published in our last issue, said it was his pleasure again to announce the continued progress in the business of the company. It was true the progress had not been rapid, owing to the difficulties they had to contend with in extending their operations, which was especially the case in India, as the Telegraph Department of the Indian Government was unwilling to allow the facilities which were necessary to the success of their subsidiary companies in that country. The increase in the dividend this year amounted to ½ per cent. on the Bengal Company's shares and 1 per cent. on the Bombay shares (making 2½ per cent., free of income tax), that result being attributable in some measure to economy in management. Their exchanges also showed an improvement in their revenues. The company had sustained great loss by the death of one of the directors, the Right. Hon. G. A. F. Cavendish Bentinck, M.P., who had been on the board for five or six years. An alteration would be noticed in the mode of distributing the dividend. The directors had been in negotiation with a large holder of vendors' shares with a view to some arrangement being come to for placing the capital on a common footing. Counsel's opinion was taken on the point, and it was deemed necessary to declare the dividend rateably on the paid-up capital of the company.

Mr. JOSEPH ADDISON (the solicitor to the company) explained the method of declaring the dividends, saying it was only the dividends on the vendors' shares that should go, to make up the deficiency of the first five years, to the ordinary shares. That was according to the opinion they had obtained. A very large holder of vendors' shares had thought fit to challenge the construction which the directors had put upon the agreement, and the case would be tried in one of the law courts on Friday.

Mr. ST. JOHN ACKERS seconded the resolution, which was carried unanimously.

The retiring directors and auditors were next re-elected.

A resolution altering the articles of association so as to allow the company to carry on any business or manufacture relating to the generation, employment, or utilisation of electricity or magnetism, or the apparatus connected therewith, was also proposed, and unanimously agreed to.

The meeting terminated with the usual complimentary votes.

The Indo-European Telegraph Company, Limited.—The directors, after adding £10,000 to the reserve fund, will recommend the payment of a dividend for the six months ended December 31st, 1890, of 17s. 6d. per share, making with the interim dividend already paid 6 per cent. for the year, and a bonus of 20s. per share, both free of income tax, making in all 10 per cent. for the year.

South of England Telephone Company, Limited.—An extraordinary general meeting of this company was held on Monday last at Winchester House, when the resolutions, passed at the meeting held on March 16th last, as reported in the ELECTRICAL REVIEW of the Friday following, were unanimously confirmed.

The Great Northern Telegraph Company of Copenhagen.—From the accounts for the year 1890, it appears that, after providing for the interim dividend of 5 per cent. per annum, and an extra dividend of 7s. 2d. per share, and also adding £66,666 to the reserve fund, a balance of £48,216 will remain to be carried forward.

Anglo-American Telegraph Company, Limited.—The directors will declare an interim dividend for the quarter ending March 31st, 1891, of 12s. per cent. on the ordinary stock, and 24s. per cent. on the preferred stock, less income tax, payable on May 1st.

The Direct United States Cable Company, Limited.—The board have resolved to pay an interim dividend of 3s. 6d. per share, free of income tax, being at the rate of 3½ per cent. per annum for the quarter ending March 31st, 1891.

TRAFFIC RECEIPTS.

The City and South London Railway Company. The traffic receipts for the 12th inst. were £827, making a total of £10,913 from the 1st January last.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending April 10th, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brasilian Company, were £4,777.

SHARE LIST OF ELECTRICAL COMPANIES.

Present Amount Issued.	Name.	Stock or Share.	Closing Quotation. (April 9.)	Closing Quotation. (April 16).	Business done during week ending April 16, 1891. Highest.	Lowest
250,000£	African Direct Telegraph, Ltd., 4 p. c., Deb. Regd. and to Bearer	100	99 —102	99 —102	...	...
1,381,380£	Anglo-American Telegraph, Limited	Stock	46½— 47½	46½— 47½	46¾	...
2,809,310£	Do. do. 6 p. c. Preferred	Stock	84½— 85½	84½— 85½	85½	84½
2,809,310£	Do. do. Deferred	Stock	11 — 11½	11 — 11½	...	...
130,000	Brazilian Submarine Telegraph, Limited	10	11½— 12	11½— 12	11 11/16	11⅝
84,500£	Do. do. 5 p. c. Bonds	100	100 —103	100 —103	...	...
75,000£	Do. do. 5 p. c., 2nd Series, repayable in June, 1906 ...	100	103 —107	103 —107	...	...
63,416	Brush Electric Engineering Ordinary, Nos. 1 to 63,416	3	2⅜— 2⅝	2⅜— 2½	2 7/16	...
63,416	Do. do. Non cum. Preference, Nos. 1 to 63,416	2	1⅝— 1¾	1⅝— 1⅝	1¼	...
50,000	City and South London Railway, Nos. 1 to 50,000	10	5½— 6½	5½— 6½	...	...
$7,216,000	Commercial Cable, Capital Stock	$100	107 —109	108 —110	108½	108¾
224,850	Consolidated Telephone Construction and Maintenance, Limited ...	14/-	7/16— 9/16	7/16— 9/16	...	...
20,000	Crompton & Co., Ltd, 7 p. c. Preference Shares, Nos. 1 to 20,000	Stock	5 — 5⅓	4½— 5⅓	5	...
16,000	Cuba Telegraph, Limited	10	10½— 11½	10½— 11½	...	...
6,000	Do. do. 10 p. c. Preference	10	16½— 17½	16½— 17½	17¼	16¾
12,931	Direct Spanish Telegraph, Limited, ... (£4 only paid)	5	3¾— 4¼	3¾— 4¼	...	...
6,000	Do. do. 10 p. c. Preference	5	9 — 10	9 — 10	...	...
60,710	Direct United States Cable, Limited, 1877	20	10¼— 10⅜	10¼— 10⅜	10⅜	10 3/16
400,000	Eastern Telegraph, Limited, Nos. 1 to 400,000	10	14⅛— 14⅜	14⅛— 14⅜xd	14⅜	14⅛
70,000	Do. 6 p. c. Preference	10	15¼— 15⅜	15¼— 15⅜xd	15⅜	...
200,000£	Do. 5 p. c. Debs. (1879 issue), repay. August, 1899	100	107 —110	107 —110	109¼	107½
1,200,000£	Do. 4 p. c. Mortgage Debenture Stock	Stock	108 —111	108 —111	...	...
250,000	Eastern Extension, Australasia and China Telegraph, Limited ...	10	14¾— 15	14¾— 15¼	15¼	14 15/16
91,800£	{ Do. 5 p. c. (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049, 3,976 to 4,326	100	103 —106	103 —106	105¼	104¾
325,200£	Do. do. Bearer Nos. 1050—3,975 and 4,327—6,400 ...	100	104 —107	104 —107	...	...
320,000£	Do. 4 p. c. Debenture Stock	Stock	105 —108	105 —108	106¾	106
135,000£	{ Eastern and South African Telegraph, Ltd., 5 p. c. Mort. Deb. 1900 redeem. ann. drawings, Registered Nos. 1 to 2,343	100	103 —106	103 —106	...	...
180,400£	Do. do. do. to bearer, Nos. 2,344 to 5,500	...	103 —106	103 —106	...	...
201,600£	Do. do. 4 p. c. Mort. Debs. Nos. 1 to 2016, red. 1909	100	99 —101	99 —101	...	...
45,000	Electric Construction, Limited, Nos. 101 to 45,100	10	5½— 6½	5½— 6½	...	...
19,900	*Electricity Supply Co. of Spain, Nos. 101 to 20,000	5	4½— 5	4½— 5	...	...
66,750	Elmore's French Patent Copper Depositing Co., Ltd, Nos. 1 to 66,750	2	1½— 1⅝	1⅝— 1⅝	...	...
70,000	Elmore's Patent Copper Depositing, Limited., Nos. 1 to 70,000 ...	2	2¾— 3¼	2½— 3½	3	2 15/16
67,385	Elmore's Wire Mfg., Ltd., Nos. 1 to 67,385, issued at 1 p.m., all pd.	2	1 — 1½	1 — 1½	1⅛	1 1/16
20,000	Fowler-Waring Cables, Nos. 301 to 20,300 ... (£4 only paid)	5	2½— 3½	3 — 4	...	...
180,227	Globe Telegraph and Trust, Limited	10	9½— 9⅝	9½— 9⅝xd	9⅝	9 3/16
180,042	Do. do. 6 p. c. Preference	10	14⅞— 15⅛	14⅞— 15 xd	15	14¾
150,000	Great Northern Tel. Company of Copenhagen	10	17½— 17⅝	17½— 18	18	17½
230,000£	Do. do. 5 p. c. Debs. (issue of 1883) ...	100	103 —106	103 —106	...	...
9,334£	Greenwood and Batley, Ltd., Ordinary, Nos. 4667 to 14,000 ...	10	10½— 11½	10½— 11½	...	...
5,334£	Do. 7 p. c. Cumulative Preference, Nos. 2,667 to 8,000	10	11 — 12	11 — 12	...	...
41,600	India-Rubber, Gutta Percha and Telegraph Works, Limited ...	10	18½— 19½	18½— 19½	19¼	19
200,000£	Do. do. 4½ p. c., Deb., 1896	100	102 —104 xd	102 —104	...	...
17,000	Indo-European Telegraph, Limited	25	40 — 42	41 — 43	43	40¾
11,334	International Okonite, Ltd., Ordinary Nos. 22,667 to 34,000	10	7½— 8½	7½— 8½	...	...
11,334	Do. do. Preference Nos. 5,667 to 17,000 ...	10	9¼— 9¾	9¼— 9¾	...	...
38,348	London Platino-Brazilian Telegraph, Limited	10	6½— 7½	6½— 7½	...	...
100,000£	Do. do. do. 6 p. c. Debentures	100	105 —108	105—108	...	...
43,900	*Metropolitan Electric Supply, Ltd., Nos. 6,101 to 50,000 (£9 paid)	10	8¾— 9½	8¾— 9½	9	...
438,984	National Telephone, Limited, Nos. 1. to 438,984	5	4⅜— 4⅝	4¼— 4½	4½	4 5/16
15,000	Do. 6 p. c. Cum., 1st Preference	10	13 — 13½	13 — 13½	13 7/16	13 5/16
15,000	Do. 6. p. c. Cum. 2nd Preference (£8 only paid)	10	10 — 10½	10 — 10½	...	...
220,000	Oriental Telephone, Ltd., Nos. 80,001 to 300,000 (11s. only paid)	1	5/16— 7/16	¼— ⅜	...	...
9,000	Reuter's Limited	8	9 — 9⅓	9 — 9⅓	...	...
209,750	{ South of England Telephone, Limited, Ordinary Nos. 1 to 2,000, 2,501 to 3,500, 93,251 to 300,000	1	⅛— ¼	⅛— ¼	...	...
20,000	Do. 6 p. c. Cum. Pref., Nos. 1 to 20,000 (£3½ only paid)	5	3 — 3½	3 — 3½	...	...
3,381	Submarine Cables Trust	Cert.	115 —120	113 —118	118¼	...
78,949	Swan United Electric Light, Limited ... ... (£3½ only paid)	5	4½— 5	4⅝— 5¼	5	4¾
37,350	Telegraph Construction and Maintenance, Limited	12	45 — 47	45 — 47	46¾	45½
150,000£	Do. do. do. 5 p. c. Bonds, red. 1894	100	102 —105	102 —105	...	...
58,000	United River Plate Telephone, Limited	5	2½— 3½	2½— 3½	3 1/16	...
146,128£	Do. do. 5 p. c. Debenture Stock ...	Stock	85 — 95	85 — 95	...	...
3,200£	Do. do. 7 p. c. Debs., Nos. 1 to 1,000 ...	100	... ...	... ...	...	...
15,609	West African Telegraph, Limited, Nos. 7,501 to 23,109	10	8 — 9	8 — 9	...	...
290,900£	Do. do. do. 5 p. c. Debentures	100	98 —101	98 —101	...	...
30,000	West Coast of America Telegraph, Limited	10	3 — 3½	2½— 3½	3	...
150,000£	Do. do. do. 8 p. c. Debs., repayable 1902 ...	100	92 — 97	92 — 97	95	...
64,174	Western and Brazilian Telegraph, Limited	15	12 — 12½	12 — 12½	12⅜	12¼
27,873	Do. do. do. 5 p. c. Cum. Preferred	7½	6¾— 7⅛	6⅞— 7⅛	7	6¾
27,873	Do. do. do. 5 p. c. Deferred	7½	5⅛— 5⅜	5⅛— 5⅜	5⅜	5⅛
200,000£	Do. do. do. 6 p. c. Debentures "A," 1910 ...	100	103 —106	103 —106	...	...
250,000£	Do. 6 p. c. Mort. Debs., series "B" of '80, red. Feb., 1910	100	103 —106	103 —106	...	...
88,321	West India and Panama Telegraph, Limited	10	2⅞— 3	2⅞— 3	3	2 15/16
34,563	Do. do. do. 6 p. c. 1st Preference ...	10	11½— 12	11½— 12	11 15/16	11 13/16
4,669	Do. do. do. 6 p. c. 2nd Preference ...	10	11½— 12½	11½— 12½	...	...
$1,336,000	Western Union of U.S. Tel., 7 p. c. 1st Mortgage (Building) Bonds	$1,000	120 —125	120 —125	...	...
175,100£	Do. do. 6 p. c. Sterling Bonds	100	100 —104	100—104	...	..
42,853	*Westminster Electric Supply Corporation, Ord., Nos. 101 to 42,953	3	3⅞— 4⅛	4⅛— 5⅛	5⅛	...

* Subject to Founders' Shares.

Latest Procurable Quotations of Securities not Officially Quoted.

Blackpool Electric Tramway Company, Limited, £10 (£6½ paid), 7¼—7⅜.—City of London Electric Lighting (Pioneer), Shares of £50, £25 paid, 27—30.—Elmore's Austrian Copper Depositing, 15s., 25s.—Elmore's Priorities, 4¼.—House to House Company (£5 paid), 4⅜—5¼.—London Electric Supply Corporation, Ordinary (£5 paid), 2⅜—2⅝.—Manchester Edison and Swan Company, £9 (£1 paid) 2s 6d.—5s.—St. James's and Pall Mall Electric Light £5, 6—6¼.—St. James's and Pall Mall, 7 per cent. pref., ⅝ to ¾ prem.—Woodhouse and Rawson Ordinary of £5 (£2 10s. paid), 2—2½.—Preference, fully paid 3⅞—4⅛.—Debentures 90—95.—Woods Electric Car, £10 paid, ¾—1.

Bank Rate of Discount.—3½ per cent. (16th April, 1891).

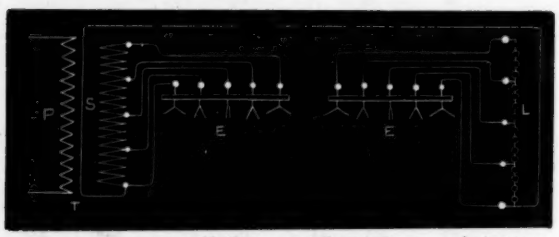
EXPERIMENTS WITH HIGH TENSION ALTERNATING CURRENTS.

MESSRS. SIEMENS AND HALSKE, of Berlin, recently invited the members of the Elektrotechnische Verein of that town to their works to witness the demonstration of a series of experiments on alternating currents under a pressure of 20,000 volts. Dr. Koepsel and Dr. Zickermann, engineers to the firm, explained that they had been experimenting with high pressure currents for about two years with the special object of testing cables, and had put together some of their apparatus in order to give the society an opportunity to see the same phenomena, which had been shown to a select party at Oerlikon some weeks previously, and had commanded so much interest among the general public. The company was assembled in a large room in which two transformers, constructed without the aid of liquid insulators each of 10,000 volt-ampères output, were placed on an elevated stage for the purpose of transforming up and down 15 H.P. of electric energy generated in the alternator, which had been stationed in another building about 200 yards distant.

In order to show that the desired pressure was really *en evidence*, the high tension current was conducted through a pair of wires of only 0·2 mm. diameter to a battery of 200 100-volt glow lamps, all connected up in series. An ordinary Siemens electric light cable was inserted, and broke down at a pressure of some 15,000 volts.

Then a high pressure cable, insulated with a layer half an inch thick of a special compound was tested, and easily withstood a pressure of 20,000 volts. A loop of about a thousand yards aerial wire, supported on oil insulators, was next inserted, and perfectly withstood the pressure applied, notwithstanding the heavy rain which was falling while the experiments were going on. Next a most striking experiment was shown demonstrating that the potential in the middle of the secondary winding of the transforming up converter is zero, while it is 20,000 at each end of the winding. While feeding a battery of lamps in series, also in the middle of the battery a point is found, where the potential is zero, and from which, towards both ends of the battery, the potential rises to 20,000.*

The accompanying photograph† gives an illustration of the



T, transformer; P, primary winding; S, secondary; L, lamps; E, electroscopes.

demonstration which followed. Two plates of metal were each connected to one terminal of the high pressure winding and placed on each side of a sheet of insulation. A volley of thin blue sparks passed through the dielectric without destroying it, and at the same time a crackling noise was heard accompanied by a strong smell of ozone.

At the end of the meeting a few experiments on the formation of the arc under this enormous pressure were shown.

The sparking distance varied considerably according to the shape of the electrodes. At 20,000 volts a spark jumped from a ball to a ball about 10 millimetres, while between two points a sparking distance of 30 millimetres, and sometimes even more, was reached.

The arc which followed the jumping over of a spark made a loud humming and clapping noise, and flapped about, being easily carried away by the slightest draught.

The arc could be drawn out horizontally to something like 100 millimetres distance between the electrodes, and even to a distance of 150 millimetres, when carbon pencils were used as electrodes, but it always remained standing up in a point.

Messrs. Siemens & Halske are directing their special attention towards the investigation of the losses by condenser action in conductors for high pressure alternating currents.

* The terminals of a battery of 200 glow lamps, all in series, were connected to the terminals of the secondary winding of the 20,000-volt transformer. At the same time a sufficient number of simple electroscopes were connected to various points of the whole system, showing the potential at all points. The accompanying sketch shows the result.

† This we do not think it necessary to reproduce.—EDS. ELEC. REV.

ON ROTARY CURRENTS AND THE ART OF MEASURING THEM.

BY HANS GÖRGES.

SINCE rotary currents have begun to attract the attention of a larger public, a few words on their nature, and on the art of measuring them, will not be considered lacking of interest. The main impulse for the following investigations was given by a series of researches on electro-dynamic rotation which were made in the test rooms of Messrs. Siemens & Halske's works in Berlin. One of the first problems encountered turned out to be the difficulty to measure the actual work performed by a number of alternating currents producing electro-dynamic rotation, which currents, for the sake of shortness, we will in the following, simply call "rotary." The method by which the difficulty of measuring the energy produced by rotary currents was overcome is to be deduced in the following lines.

The practical development of the transmission of power by rotary currents has been almost contemporaneously attacked by a number of investigators. Mr. Haselwander's work in this direction forms the subject of the German patent H 9,084, and Mr. Von Dolivo-Dobrowolsky has recently given a description of his experiments in the same line in the the *Elektrotechnische Zeitschrift*, but a regular definition of what is to be understood by "rotary currents" has not yet been offered.

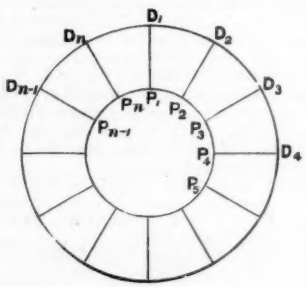


FIG. 1.

One might, perhaps, say that rotary current consists in a system of alternating currents of equal periods connected together, the phases of which differ from each other according to a set simple relation in such a way that suitable appliances provided rotating magnetic fields of nearly constant intensity will be generated in a system which is mechanically at rest. By this all-important quality rotary current is capable to drive asynchronous electromotors, which will start when heavily loaded. Herein lies its great advantage over ordinary alternating currents, because it can be generated and transformed as easily as the latter.

To be more exact let us assume a generator with n terminals, *i.e.*, points P_1, P_2 . . . P_n, from which issue alternating currents of the same period. These terminals may be distributed in a circle, and between two neighbouring terminals equal mean pressures may occur. From the terminals may issue n conductors, the currents in which are to be very nearly equal. The difference of phase between the currents in two neighbouring conductors is assumed to be equal all round, and is therefore, to amount to $\frac{360^\circ}{n}$ degrees. This means that the

currents pass through their maximum intensity in cyclic order. The outer end of every main is to be connected with the outer ends of the two neighbouring mains by conductors in which, consequently, currents also of equal mean intensity but of different phases will flow. The whole system is shown in fig. 1.

In the simplest case, which most likely is the most important in practice, three terminals, P, only are used. Such a distributing system can easily be put together in this way: Wind an iron ring with three equal coils each of which takes up one third of the circumference and let it rotate in a constant magnetic field, such as that of an ordinary two-pole continuous current generator. In the three coils alternating currents will be generated; but these alternating currents will have unequal phases because the coils pass the north pole at different times. The maximum intensity of current will occur successively in every coil in equal intervals of time. One might employ six conductors to carry off these currents and would then have three wholly disconnected circuits, as shown in fig. 2. Such a system we would not call "rotary

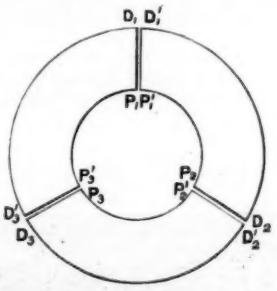


Fig. 2.

current." If, however, you unite every pair of parallel running conductors as shown in fig. 3,* "rotary current" is obtained, one of the peculiarities of which is, that every conductor in turn serves as a return wire for the two others. It will be observed that in this system ramifications occur. The current coming from P_1 is split into two parts at

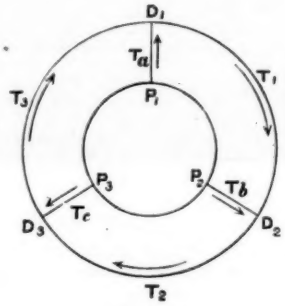


Fig. 3.

D_1. One part flows to D_2 and another to D_3, to return respectively to P_2 and to P_3. The greater part of the two—which may be the one flowing between D_1 and D_2—will, moreover, be split again in D_2, the greater part flowing from D_2 to P_2, the smaller part from D_2 to D_3 and from there on to P_3. We will designate the currents issuing from the points P by I_a, I_b, I_c, and will call them positive when they flow from P to D. The three other currents may be I_1, I_2, I_3, and we will call them positive, when their direction coincides with the sense of rotation of the hand of the clock. The positive directions are designated by arrows in the diagrams. We will also call the branches I_a, I_b, I_c, the "mains" and the branches I_1, I_2, I_3, the "connectors." Generally speaking energy will be consumed in all the six branches, but we are specially interested in those two cases in which useful work is only performed either in the mains or in the connectors. The diagrams, figs. 4 and 5, correspond with these two cases. The first diagram explains itself, the latter is derived from diagram, fig. 3, by leaving out the connectors altogether and uniting the three points D.

In the ideal case, the currents, pressures, and works will be equal in the three mains as well as in the three connectors. The currents I_a, I_b, I_c, and the pressures between neighbouring terminals, which we will designate in the following by E_α, E_β, E_γ, can be measured most easily, but the question arises whether these values suffice for the measurement

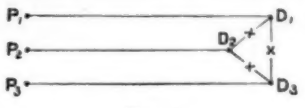


Fig. 4.

of the work performed, and if so, how you ought to proceed.

In order to investigate the most manifold relations, we will make use of the polar diagram, which, though already

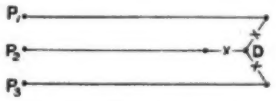


Fig. 5.

well known, may be once more explained. It is strictly correct, when all magnitudes vary like sines, and have the same periods.

Let a straight line, M N, fig. 6, rotate round the fixed point O, in the same sense as the hand of the clock, with constant velocity and such, that one whole turn corresponds exactly with one whole period of the alternating current.

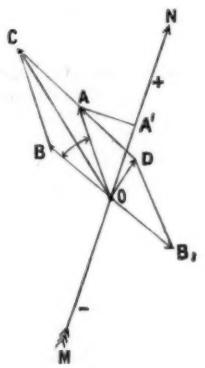


Fig. 6

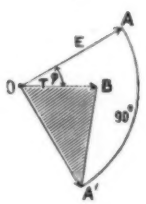


Fig. 7.

O N may be the positive, O M the negative direction. Then if we draw any straight line, O A, the length of which expresses the maximum value of a current intensity (*i.e.*, the amplitude of the current), its rectangular projection, O A^1 on M N, gives the value of the current in that moment in which the line M N has the direction drawn in the diagram. The current intensity reaches its maximum when M N and O A coincide, diminishes and becomes zero when M N reaches a position rectangular to the direction of O A, then becomes negative, because the projection falls on to the negative side of M N, and so forth. If O B means another current intensity, it is evident that it will reach its maximum value sooner than the first current, by a space of time which is equal to the time consumed by the line, M N, to describe the angle, B O A. Now since the time consumed by M N in a whole period is equal to the period of the alternating current, the angle, B O A, is proportional to the difference of phase between the two currents, O A and O B. This difference of phase may either be expressed by the angle, or else by fractions of the period. Therefore, the lines, O A and O B, define the current intensities, not only with regard to their value, but also with regard to their phase. In this diagram pressures, magnetisations, in fact all magnitudes which vary like a sine function, and have the same period, may be expressed in the same way. In practice the amplitudes themselves are less important than the mean values measured by the dynamometer. But since these values possess to the first named the constant relation of $1 : \sqrt{2}$ in the following, the lengths in our diagrams will be used only to express the latter values.

When two values O A and O B are to be added, this is done

* In this diagram read I for T.—Eds. Elec. Rev.

according to the parallelogram of forces by describing a parallelogram, O A C B, the diagonal O C of which expresses the desired sum. When O B is to be subtracted from O A, O B is prolonged beyond O to B_1 so that $O B_1 = O B$, and the parallelogram, O A D B_1 is described, when O D will be the desired difference. In the following the sums and differences found in this way will be designated by indices which express the sum or difference of the indices of the components. Thus if

$$O A = I_1 \text{ and } O B = I_2$$

then

$$O C = I_{(1+2)} \text{ and } O D = I_{(1-2)}$$

The electrical work, A, is expressed by the product

$$A = E \cdot I \cdot \cos \phi$$

Wherein E and I mean the values of pressure and of current intensity, and ϕ the difference of phase between E and I. The value of A can easily be expressed geometrically. Turn one of the two lengths, for example E in fig. 7 to an angle of 90° out of its original position round O as a centre, so as to give it the position $O A_1$, then the triangle, $O A_1 B$, is equal to one half of the work, A.

We now suppose that all alternating currents and pressures vary according to the sine law, and that the load in all three branches of our system is the same. Therefore,

$$\left.\begin{aligned} I_a = I_b = I_c \\ I_1 = I_2 = I_3 \end{aligned}\right\} \quad (1)$$

and the angle of phase difference between I_a, I_b and I_c, and between I_1, I_2 and I_3 will be 120°.

We begin by drawing the currents, I_1, I_2 and I_3, fig. 8.* From the diagram, fig. 3, it follows, that

$$I_a = | I_1 - I_3 | \quad (2)$$

(The straight bracket is meant to express that I_1 and I_3 are to be added geometrically.) We therefore prolong I_3 beyond O by its own length, and find I_a, according to the rule given above, as the resultant of the components, I_1 and $-I_3$. From this it follows directly that I_a differs in phase from I_1 by 30°, and therefore reaches its maximum value later than I_1, moreover, that I_a is larger than I_1, but smaller than 2 I_1, namely,

$$I_a = 2 \cos 30° \cdot I_1 = 1{,}732 \cdot I_1 \quad (3)$$

Now I_b and I_c may be put in by turning I_a 120° in both senses respectively.

Further, we will suppose that the pressures in the mains, E_a, E_b, E_c, all differ in phase from their corresponding currents, I_a, I_b, I_c, to the same amount, which we will call φ_a, and that likewise the differences in phase between the pressures in the three connectors and their respective currents, I_1, I_2, I_3, are equal, and shall be called θ_1, then the works may be expressed as follows:

$$\left.\begin{aligned} A_a = E_a \cdot I_a \cdot \cos \varphi_a \\ A_1 = E_1 \cdot I_1 \cdot \cos \theta_1 \end{aligned}\right\} \quad (4)$$

Since $I_a = | I_1 - I_3 | = 2 I_1 \cdot \cos 30$

and $E_{(a-b)} = | E_a - E_b | = 2 \cdot E_a \cdot \cos 30$

it follows that

$$A_a = E_{(a-b)} \cdot I_1 \cos \varphi_a$$

and therefore

$$A_a + A_1 = T_1 (E_{(a-b)} \cos \varphi_a + E_1 \cos \theta_1).$$

Now, from fig. 9 it is evident that

$$E_{(a-b)} \cos \varphi_a + E_1 \cos \theta_1 = E_{(a+1-b)} \cdot \cos \psi$$

in which ψ means the difference of phase between $E_{(a+1-b)}$ and I_1. We obtain therefore

$$A_a + A_1 = I_1 \cdot E_{(a+1-b)} \cdot \cos \psi. \quad (5)$$

Now, $E_{(a+1-b)}$ is nothing else than the pressure between the terminals P_1 and P_2, fig. 3. But the current, I_1, cannot be measured at the generating station and in certain cases cannot be measured at all. If, therefore, a wattmeter is connected up so that the current coil takes up the current, I_a, while the pressure coil is inserted between the terminals P_1 and P_2 and P_1 and P_3 respectively, it will indicate the works

$$\left.\begin{aligned} A' = I_a \cdot E_{(a+1-b)} \cdot \cos (30 + \psi) \\ \text{and} \quad A'' = I_a E_{(a+1-b)} \cdot \cos (150 + \psi) \end{aligned}\right\} \quad (6)$$

because the difference of phase between I_a and $E_{(a+1-b)}$ is larger by 30° than that between I_1 and $E_{(a+1-b)}$, fig. 9.

The difference between the two expressions can be given by

$$A' - A'' = I_a \cdot E_{(a+1-b)} \cdot 2 \cdot \cos 30 \cos \psi$$

and taking according to (3)

$$A' - A'' = (2 \cdot \cos 30°)^2 \cdot I_1 \cdot E_{(a+1-b)} \cdot \cos \psi$$

$$= 3 \cdot I_1 \cdot E_{(a+1-b)} \cdot \cos \psi \quad (7)$$

A comparison between (7) and (5) shows that

$$A' - A'' = 3 (A_a + A_1) \quad (8)$$

i.e., the total work performed by the rotary current.

Therefore, supposing that all three equivalent branches of the rotary current system are equally loaded, the total work performed thereby can be measured by two readings.

Insert the current coil of your wattmeter into one of the mains, connect one end of the pressure coil with the corresponding terminal, and connect the other end of the pressure coil first with the second and then by a switch with the third terminal.

The two works so found are added when the dynamometer turns in the same sense in both measurements, because according to our suppositions with regard to positive and negative directions of the currents in that case one of the works has been measured negatively.

In the diagram, fig. 8, the total work performed in the

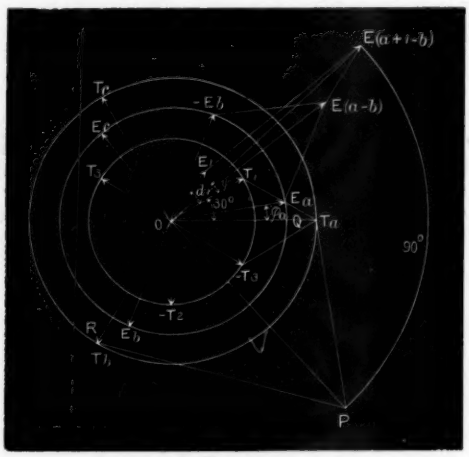


FIG. 8.

system can be expressed as follows. Turn length $E_{(a+1-b)}$ round O as a centre by 90°, in the sense of the hand of the clock so as to give it the position O P, and connect P with the ends Q and R of the lengths I_a and I_b. The quadrangle thus obtained then expresses one half of the total work performed in the system, because it is indifferent whether you combine the pressure $E_{(c+3-a)}$ with I_a or the pressure $E_{(a+1-b)}$ with I_b, since we have assumed the load to be equal in all branches. The case when there are no differences of phase between the pressures and currents would be of special interest. Since to obtain the work performed by alternating current the product of the current into the pressure has to be multiplied by the cosine of the angle of phase difference between the two, the maximum work is obtained of a given current and pressure when the difference of phase is zero. In this case the pressure $E_{(a+1-b)}$ has the same phase as I_1, therefore a difference of phase of 30° from I_a. Therefore O P lies in the middle between I_a and I_b and the works O P Q and O P B will be equal. On the contrary, should differences of phase take place, O P will always appear twisted against the sense of the hand of the clock, and the work O P Q will be smaller than the work O P R. *Vice versâ, we may conclude that no differences of phase between pressure and current occur in the system when both works, A' and A'', are found to be numerically equal.* This case is specially important for the use of motors.

(To be continued.)

* In this diagram read I for T.—EDS. ELEC. REV.

PROCEEDINGS OF SOCIETIES.

Institution of Electrical Engineers, April 9th, 1891.

DISCUSSION ON MR. ESSON'S PAPER, "NOTES ON THE DESIGN OF MULTIPOLAR DYNAMOS."

(*Authorised Abstract.*)

Prof. S. P. THOMPSON said he regretted that Mr. Esson had used the word "volume" for something which was not of the nature of *volume*, and he thought that the meaning assigned to it was not the *ampère-turns* on the armature, but twice that number. The formulæ for the theoretical load limit given seemed incorrect owing to neglect of leakage. Speaking of the comparison of the two and four pole machines shown in figs. 3 and 4, he said a better comparison would have been obtained by considering figure 4 to be a two-pole machine with a double magnetic circuit, both the top poles being N (say) and the two bottom ones S. The surfaces of the two armatures would still be the same and so far as he could see, their limiting outputs would remain unaltered. It was thus, not a question of the number of poles, but of the number of magnetic circuits. Again, on slip 3, relations between the "volume of current," and the diameters of ring and drum armatures were given, but no mention as to whether these were intended to apply to machines with single or double magnetic circuits was made. In his (Prof. Thompson's) opinion it would have been better to distinguish between the two types, for he believed the proportions should be different, and that an armature working in a double circuit field could safely carry a greater current than when in the field of a single magnet. Referring to "cross-induction," he remarked that some years ago he suggested that pole-pieces should be laminated or have air spaces parallel to the lines of force, in order to counteract the weakening of the field near the trailing horns. As regards the proportions of iron and copper in the magnets of direct and alternate current multipolar dynamos, he thought a more modern type of alternator than that shown in figure 2 should have been chosen, for in that the amount of copper was prodigious. In conclusion he thanked the author for the many good things contained in the paper, and said the data there given would be very useful in designing machines.

Mr. KAPP, speaking of the laminated pole pieces mentioned by Dr. Thompson, said Mr. Joel adopted a similar plan in 1885 with the idea of getting more corners on his magnet, and consequently obtaining a greater magnetic pull. He himself had also designed multipolar machines with a deep slot in the middle of each pole piece and found that the armature reactions were halved thereby. Referring to magnetic circuits of four-pole machines he did not agree with Mr. Esson that a field of the Elphinstone-Vincent type, fig. 4, was more efficient than the symmetrical Gramme field shown in fig. 6,

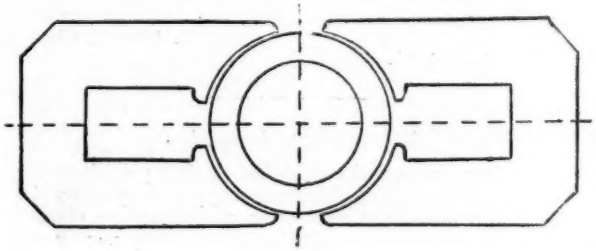


FIG. 4.

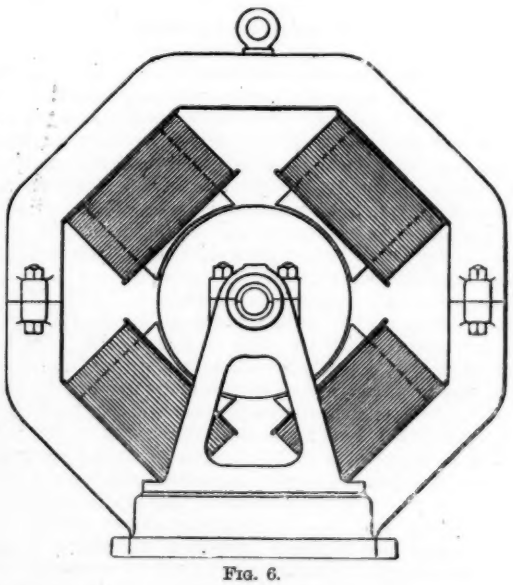


FIG. 6.

and thought that the author's conclusions might be due to wrought iron being wholly used in the one and mostly cast iron in the other. Taking the same material he (Mr. Kapp) found that of the three kinds of four-pole magnets shown in figs. A, 4, and 6, the first or "Ironclad" form, fig. A, was the heaviest and required most wire, whilst the last, fig. 6, was lightest and requires the least wire. In comparing bipolar machines with multipolar ones, he pointed out that it was necessary to make the armatures of the latter machines larger in order to obtain sufficient space between adjacent pole pieces. This, together with the fact that only shallow armature cores are needed, makes the ventilation of multipolar machines very much better than bipolar ones. This point, he thought, had been overlooked by the

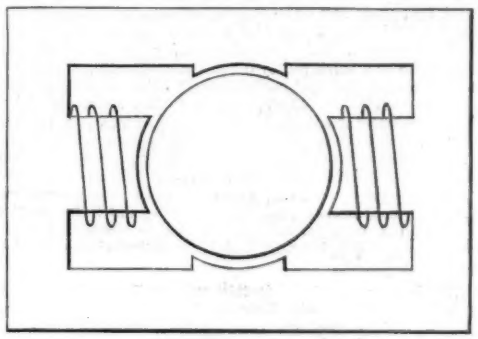


FIG. A.

author. Although Mr. Esson's formula for the "volume of current" carried by armatures agreed fairly well for well designed machines, it must, he said, not be used indiscriminately, and that if a larger armature be made with a view to measuring the "volume" of current, the field magnets must also be increased.

Mr. F. V. ANDERSEN remarked that Mr. Esson's formulæ for the load which could be safely carried by armatures without sparking, did not include the number of commutator segments. He thought that increasing the number of such segments tended to diminish sparking, and enquired whether sparking could not be prevented by this means.

The further discussion of the paper was adjourned to the 16th inst.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1890.

836. "Improved means for preventing disturbing action in long telephonic circuits." E. GWOSDEFF and H. BUNGE. Dated January 16th. 8d. Claims:—1. The described means for preventing disturbing action in telephonic circuits, consisting in the use of branch conductors between the line wire and return conductor, or generally between the outward and return terminal screws of telephonic circuits in which branch conductors are introduced, either resistances, electro-magnets, or condensers. 2. The use in long telephonic lines of discharge conductors between line wire and return conductor, in combination with contact closers or devices for automatic intermittent making and breaking of the communication with the discharge conductor, substantially as described.

1,246. "Improvements in means for the electrolytic generation of chlorine and compounds of chlorine with earthy bases, more especially intended for bleaching purposes." D. G. FITZ-GERALD and A. C. FALCONER. Dated January 23rd. 4d. Relates to means for the electrolytic generation of chlorine and compounds of chlorine with earthy bases, thereby producing fluids possessing strong bleaching properties, although the invention is not limited to bleaching operations. The conductors hitherto used as anodes in the electrolysis of chlorides in solution have hitherto been carbon and platinum. According to the invention the inventors employ anodes of peroxide of lead in the compact, coherent and conductive form in which it is known as lithanode. 1 claim.

1,658. "Improvements in and connected with electricity meters." C. P. ELIESON. Dated January 30th. 8d. The inventor provides for ascertaining the quantity of current which has passed through such liquid either by metering the volume of gas generated or the quantity of liquid decomposed. 8 claims.

2,241. "Improvements in and relating to electric vote indicator and recorder for legislative bodies." W. H. ROBINSON. Dated February 11th. 8d. Comprises a system by which the votes of members of legislative or other Parliamentary bodies may be instantly indicated and recorded, and by which the result may be noted at a glance from any part of the Parliamentary chamber, and by which each member's vote is telegraphed back to his desk and is there verified as to its character, whether "aye" or "nay;" it is also designed that the votes shall be automatically counted by electrical action. 10 claims.

2,255. "Improved electric switches and transmitting apparatus for use in telegraphic or telephonic systems." G. M. CRUIKSHANK. (Communicated from abroad by M. Schwabacher, of Frankfurt-on-the-Maine.) Dated February 12th. 8d. The arrangement or installation is so designed that besides giving automatic communication, not only are the connections prevented from being disturbed by a third but

the return to the position of rest follows independently, the great advantage gained being that the connections with the places called up can be automatically severed after the traffic is over. 2 claims.

2,527. "Improved method for the regulation of the carbons in electric arc lamps by the expansion and contraction of metallic wires." O. CORNWELL. Dated February 17th. 8d. Attached to the wire or wires is a lever and weight in connection with a cord passing over a pulley, when the wire expands the lever is lowered, and by means of a weight suspended on the same cord on the opposite side of the pulley the cord becomes taught, thus causing friction on the pulley, turns it slightly in one direction. The carbon rod being suspended on a cord, and made fast on to the rim of a second pulley on the same spindle, but tending by gravitation to fall in an opposite direction to the movement transmitted to the first pulley by means of the lever and weight, on to a third pulley on the same spindle, is connected by means of a cord, a dash pot containing glycerine or oil to prevent the carbon from descending too quickly, and thus short circuiting the arc; when the current enters the lamp the wire or wires become hot and expand, thus lowering the lever and tightening the cord over the pulley, turning it in one direction, and thereby separating the carbons and establishing the electric arc; when the arc becomes too wide by the consumption of carbon, the current becomes less, the wire becomes cooler, and by contraction draws up the lever until the friction becomes so small as to allow the carbon rod to descend by its own weight in an opposite direction, and thus automatically regulate the electric arc. 3 claims.

3,163. "Improvements in electric switches." P. P. ALEXANDER. Dated February 27th. 6d. Consists of an axis carrying radial contact makers, which may conveniently be brushes. These contact makers are preferably fixed at equal distances apart along the axis, and are also inclined to each other at equal angles. Parallel to the axis is a straight row of other contact makers, consisting of segmental plates, each being a portion of a cylinder whose axis is the axis carrying the radial contact makers. Each of the segmental contact makers is opposite to one of the radial contact makers and within its reach, and their length is such that the angle they subtend at the axis is about equal to the angle between the radial contact makers. It results, therefore, that the circuit is always completed, one or other of the radial contact makers being always upon one or other of the curved plates. 2 claims.

3,335. "An improvement in holders for incandescent electric lamps." A. SCHIRNER. Dated March 3rd. 6d. The inventor imparts to the sleeve of the holder such resiliency that it permanently exercises a moderate pressure from all sides on the screw-threaded mounting of the lamp, and that if the lamp is screwed in with too much force, the sleeve yields peripherally and allows the threads of the mounting to slip over from the first engaged threads of the sleeve to the preceding ones. 2 claims.

5,062. "Improvements in and relating to electric railways, and more especially to the overhead switches and overhead contacts." C. J. VAN DEPOELE. Dated April 1st. 8d. The invention consists essentially in the construction and arrangement of the overhead contacts; in means for reversing the same when the direction of motion of a car is to be reversed, and in the switches for switching off the overhead contacts. 10 claims.

8,427. "Improvements in electric arc lighting." A. APPS. Dated May 31st. 6d. The inventor feeds the arc flame with hydrocarbon vapour by causing it to pass up through the lower carbon from a reservoir containing oil or other source of the vapour in or near the lower end of the carbon. The upper carbon is of the usual sort. 4 claims.

CORRESPONDENCE.

The Invention of the Dynamo.

In the last issue of the ELECTRICAL REVIEW, Mr. Tanner has called attention to the 1854 specification of Soren Hjorth. I should be very sorry if the impression should go forth that I have desired at any time to spirit away the claims that Hjorth may fairly be considered to have. I, like many others, only became aware of Hjorth's specification from Mr. Dredge's book, published in 1882, sixteen years after my 1866 machine had been constructed.

My original dynamo was designed to be self-exciting, and it was, I think I may safely say, the first self-exciting dynamo constructed with field magnets of soft iron only.

Sir Charles Wheatstone and Dr. Werner Siemens, independently of myself and of each other, also discovered the reaction principle, but the apparatus their discoveries were made with, in both cases, was not designed for the purpose of self-excitation. I am sorry to have felt myself compelled to emphasise these facts, but the persistent efforts made from time to time to spirit away my dynamo-electric claims force my hand.

In the printed description describing my exhibit at the Inventions Exhibition of 1885, reference was made to the 1854 specification of Soren Hjorth. It was stated "that if a machine acting as described in the Hjorth specification had been actually made it would have been an approach to the dynamo principle, and that machines of the *pure* dynamo type would *in all* probability have been made *earlier* than 1866."

The first lecture of a course on dynamos was delivered by Dr. Silvanus Thompson at the Royal Institution last Saturday, and he made reference to my 1866 machine. Dr. Silvanus Thompson has, however, rendered it quite impossible for me to hold any discussion with him, for if words have any meaning at all, what he stated from the Royal Institution pulpit, in effect, amounts to a charge that I am absolutely untruthful, and that what I have stated in reference to my dynamo-electric claims is not entitled to any credence.

In my schoolboy days we used to consider that when a controversy had passed a certain stage, it could only be satisfactorily dealt with physically; but the world has grown older and times have changed since then; reverence for etiquette and propriety seem to have largely replaced that love for the whole truth, and that love for its assertion at all costs, for which the typical Englishman was at one time credited.

There is a ridiculous side to all things, and we are told there is only one step between the sublime and the ridiculous. The attitude which Dr. Thompson would seem to consider it not derogatory to himself to assume, has, in my opinion, pushed matters over the border line. I have a lively remembrance of a certain play in which the late Mr. Robson used to bring down the house by saying in his inimitable manner, "With a righteous cause and a good thick stick, I think I shall thrash him." Now, I am disposed to consider that the two not very ancient judgments given altogether in my favour in the law courts, even if they stood alone by themselves, would constitute a fairly thick stick, and I look forward with a certain degree of composure to a time arriving when Dr. Silvanus Thompson, and also certain other physicists who wrote their names in very large type in the Patent Office during the booming period of the electric light, may have it brought home to them that, in the long run, it would have been to their interests to have treated me with greater fairness.

S. Alfred Varley.

April 13th, 1891.

Elmore Copper Companies.

You have for some time past thought fit to publish a series of statements regarding the Elmore Copper Companies which are utterly false. The reason for the appearance of these articles is at present a trifle obscure, but they may or may not be written for the same disgraceful object as it is generally understood certain publications in the City appear for—publications which degrade the honourable profession of journalism.

I now note that in your endeavour to depreciate the property owned by these companies you have allowed one Alexander Watt to slander me—calling me a thief by implication—and have given him in return for such service a gratuitous advertisement for a book which consists chiefly of a collection of ancient receipts and formulæ used in the electro-plating trade, and which he is pleased to honour with the title of "Electro-Deposition." This person is good enough to say that I have "plucked" from a patented process of his something of value.

Now, before enquiring what value there is in Mr. Watt's patent, or as to his title to it, I would ask if you took any of those precautions which the editor of a respectable journal is supposed to take to satisfy himself of the truth of the statements made by his correspondents and published by him, particularly when such statements constitute such a serious charge as this Mr. Watt makes against me. Either you have not done so or you are so grossly ignorant of the subject under discussion that you are utterly incapable of making any such enquiry. If you have "written down" an electro-chemist as you have "written down" the processes of my brother and myself, and are so lamentably ignorant of the history of the electro-metallurgy of zinc that you do not know that the use of an acetate of zinc solution is almost as old as the art itself, it is high time that the Council of the Institution of Electrical Engineers (to which I understand you belong) tell

you in plain language to read the subject up, and until you acquire some knowledge of the same, either cease opening your columns to disappointed patentees or cease your membership of that honourable society.

You have sent forth to the electrical fraternity in your columns (so that it may be freely copied into the City papers of a certain kind) Mr. Watt's statement that I have stolen from his patent "*his invention*" (*sic*). The following extract from unquestionable authorities will show just how much title Mr. Watt has to the honour of being the inventor or discoverer of acetate of zinc as an electrolyte, and which electrolyte he alleges I have stolen from him :—

In George Shaw's "Manual of Electro-metallurgy," 2nd edition, published in 1844, will be found the following on page 85 : "Acetate of zinc is formed when oxide of zinc is dissolved in acetic acid. The solution of this salt answers well for the electrical reduction of the metal."

Where is my "temerity" or "audacity" after this quotation, published in a book 47 years ago, in saying in my specification that although I have mentioned zinc sulphate as the salt treated, other compounds of zinc, such, for instance, as the acetate, may be similarly treated.

It would appear to me that the "audacity," "temerity," "effrontery" (all expressions used by your classical contributor), are all on the side of the person who obtains a *valueless* patent for something which was described 47 years ago.

But Mr. Watt, in his long experience as a "consulting chemist," may have missed this author, and I therefore take you to a better known one. On page 210 of the third edition of "Elements of Electro-metallurgy," by Alfred Smee (the preface of which is dated February 18th, 1851), will be found the following statement :—"The acetate of zinc may be formed by digesting oxide of zinc in pyroligeneous acid, or by making zinc the positive pole in that fluid. It is a very good solution for obtaining reguline metal by the single battery process."

The same author then goes on to describe other organic acid compounds of zinc used for electro-deposition. It is surely a pity that Mr. Watt did not look up so well-known and valued an authority as Smee before undertaking that laborious series of experiments which he is so fond of referring to. It is to be noted that this publication appeared 40 years ago. However, I do not rely on one or two anticipations only, but will proceed to quote more.

On September 8th, 1841, Oglethorpe Wanklein Barratt filed a patent No. 9,077, in which the following occurs :—"The muriate or acetate of zinc or the solution of zinc in muriate of ammonia, or the sulphate of zinc of commerce, may also be used as an electro-depositing solution." Surely these are distinct enough even for Mr. Watt, and go to show that he must have wilfully overlooked these prior publications or been very remiss in his search after the truth. Possibly Mr. Watt was so busily engaged dealing with a problem that appeared to him almost beyond solution (but which had been fully described by others 40 to 50 years previously), that he neglected to consult such old authorities, as, for his and your edification, I will point out a few more modern anticipations.

Dr. Alexander Classen, Professor of Chemistry and Director of the Inorganic Laboratory in the Royal School of Technology at Aachen, issued a second edition of his book, entitled, "Quantative Chemical Analysis by Electrolysis," which is dated, "Aachen, September, 1885." This was translated into English, and published in 1887. On page 63 will be found the following :—"Parodi and Mascazzini determined zinc by electrolysis in a solution of the sulphate to which has been added sodium acetate and citric acid to acid reaction." The same author on the same subject says :—"Riche reduces zinc from a solution of the acetate with excess of ammonium acetate obtained by super-saturating with ammonia and acidifying with acetic acid."

Dr. Gore, in his book entitled "Theory and Practice of Electro-deposition," written in 1856, and republished with additions as to the thermic relations of electrolyses, and relating to dynamo machines, says on page 73, "Zinc salts." "There are a variety of salts of this metal in ordinary use, the most common of which are the sulphate chloride, nitrate, and acetate." Note the expressions "ordinary use" and "most common." The same author on the same subject says : "The acetate is made either by dissolving zinc in strong acetic acid to saturation, and then evaporating and crystallising the solution, or by adding a solution of acetate of lead to a solution of sulphate of zinc, as long as it produces a precipitate ; then filter, evaporate, and crystallise the liquor."

Many other quotations could doubtless be found had one only the time to look them up, but I think sufficient has been quoted to show whether or not Mr. Watt's claim to the exclusive use of acetate of zinc as an electrolyte is a vampire claim or a good one, and they show, I think, how much I have "plucked" from his patent—which, however, he prefers to term his invention.

It will be observed that some of the quotations also anticipate Mr. Watt's second patent (1888), namely, Classen, page 63, in which he uses a mixed electrolyte containing sulphuric and citric acids, and Gore, page 73, in which is described the process of precipitating lead from an acetate solution by means of sulphate of zinc. I, of course, am chiefly concerned with the first patent, in connection with which he propounds the absurd proposition that I have stolen from his something which I have clearly shown he never possessed. I, however, think it advisable to point out the anticipation of his second patent, as to quote Mr. Watt it may be "liable to mislead the public."

In concluding this part of my letter, I would direct your attention to page 265 of Dr. Gore's book, entitled "The Electrolytic Separation of Metals," where he says, referring to Watt's patent No. 6,294, of 1887 : "The patentee states that when the solutions of zinc are found to contain any considerable proportion of lead, iron, &c., these metals may be precipitated as sulphides by passing a stream of sulphuretted hydrogen through the liquors while in an acid condition." "This method," says Dr. Gore, "is used by chemists to precipitate zinc from acetic acid solutions and leave iron."

The accuracy of Dr. Gore's remarks may very easily be tested by any one having but a slight knowledge of chemistry, and yet we have the patentee of this process describing himself as a "consulting chemist."

It would be really interesting to know what his clients consult him about—not, I should think, to obtain such information as this.

Having thus disposed of Mr. Watt's untenable claim and shown that the acetate of zinc as an electrolyte is public property, I may now proceed to make a few general remarks on his ill-considered letter.

It would appear from his opening paragraph in *re* "gleaning" patent specifications coupled with the above anticipations, that Mr. Watt is, in all probability, an adept at what he accuses me of, that is, "patent making."

Your correspondent says that the Elmores have made many attempts, notably in "various parts of Wales, to deposit zinc from its sulphate solution, and ingloriously failed in every such attempt." Now, with regard to this, I give Mr. Watt the lie direct, and beg to say that this misrepresentation as to the many visits, resolves itself into the one and only visit I ever paid to Wales for the purpose of endeavouring to deposit zinc, and that visit, so far as my recollection serves me, was compulsorily one to fulfil the terms of an agreement made by someone else, and which experiments had absolutely no connection with my present patents.

Is it not extraordinary that Mr. Watt did not oppose the grant of my patent during the time allowed by the Patent Office for that purpose, instead of now writing complaining of my "audacity," and endeavouring to show that I have stolen from him something which I have shown to be public property.

I note that in the last paragraph of Mr. Watt's letter he refers to the Elmore Copper Companies, and promises frightful revelations as to the validity of the Elmore patents ; but these revelations have been so often promised by the Electrical Review already, that I am afraid some of your City contemporaries who thrive and fatten on the profitable occupation of "company erecting," will shake their heads sadly and say that it looks like a cry of wolf repeated once too often. And they will not even give you the satisfaction of seeing something of this kind in their publication. "Our valued contemporary, the *Electrical Reviler*, who so distinguished themselves by their research into the 'Marchant Engine,' have sent us the following which is worthy of the 'deepest consideration,' as it should without doubt materially assist the 'bears,' with whom we are at present dealing."

I may say that on the subject of the Copper Companies my

mouth is practically closed by my directors, who are at the head of the business to guide its policy; but, without overstepping my instructions, I may say that the quality of the copper deposited by the Elmore process can, as the editors of the ELECTRICAL REVIEW would no doubt say, look after itself.

We do not go to men like Alexander Watt and the editors of the ELECTRICAL REVIEW for an opinion upon such a subject, but to the people who buy and use the goods sold by the Company.

It may be news to you that by far the large majority of the people supplied with the goods manufactured by Elmore's Patent Copper Depositing Company, Limited, have sent repeat orders—in many instances the orders have been repeated several times—and they have almost always given the Company flattering testimonials as to the quality of their goods. This is without doubt the best answer to your unjustifiable attacks.

I would also draw attention to a fact that you, with the great interest you take in the Elmore Companies, must be aware of, namely, that I am a very large shareholder in Elmore's Patent Copper Depositing Company, Limited, Elmore's Wire Manufacturing Company, Limited, Elmore's Foreign and Colonial Company, Limited (founders' shares), and in the Elmore's French Company, Limited, and that although the market price of these shares has been respectively (so far as I remember) 8¼, 4¼, 19¼ and 4, I had sufficient confidence in the success of these companies to stick to every share I ever held, and the only effect of a low quotation for Elmore shares is to allow those who know best to get in a good thing at a low price, and this the vendors very seldom fail to do. You might also inform your readers that the actual vendors and members of the Elmore family to-day hold more shares in the companies than ever they did.

In conclusion, I have only to say that for your own reputation's sake it would be advisable for you when criticising a process in which any scientific knowledge is required, to engage someone who is capable of undertaking such work, and not to rely upon a "consulting chemist" who patents chemical impossibilities, or you may find yourself in the same humiliating position in regard to matters electro-metallurgical, as you did in regard to matters mechanical when you understood to "boom" the Marchant engine.

Having now shown the incapacity of your correspondent, and the utter regard for the truth displayed by him, I have now to ask you to give equal prominence to this as you did to your slanderous correspondent's diatribe, and I beg to offer you and Mr. Watt the opportunity of repairing the wrong you have done me by publishing a full and ample apology, otherwise I shall take advice as to the best method of affording you an opportunity of demonstrating the truth of your statements, and Mr. Watt of having that "consideration" bestowed on his views that you so ardently desire on his behalf.

A. S. Elmore.

April 14th, 1891.

[This letter is ostensibly in reply to that of Mr. Alexander Watt on the subject of an Elmore patent for the deposition of zinc, which we published last week. Mr. A. S. Elmore has, however, been unable to resist the opportunity of incorporating in his reply to Mr. Watt a series of remarks addressed to ourselves. Mr. A. S. Elmore is doubtless aware of our invariable rule of affording every opportunity to correspondents of presenting to our readers any information of interest, and as it often happens that two people do not see the same thing in the same light, our readers have the advantage of forming an opinion of their own after the presentation of both sides. The controversy between Mr. Elmore and Mr. Watt we leave to Mr. Elmore and Mr. Watt. Our columns are open to both. We have, however, something to say to Mr. Elmore on his remarks addressed to ourselves. He says we have thought fit to publish a series of statements regarding the Elmore Copper Companies which are utterly false. We have published statements of our own, and we have published statements from others, amongst them being some emanating from those representing Elmore interests. We are responsible for our own statements, and know them to be substantially accurate. If the others are utterly false we regret having given them currency. Mr. Elmore apparently considers the reason for our attitude on the question of the Elmore Companies is at present a trifle obscure, but it may or may not be for some disgraceful object which degrades the honourable profession of journalism. Any obscurity which there may be must be ascribed to Mr. Elmore. If we say things plainly we do all we can do. We cannot also provide eyes for those who will not see, or ears for those who will not hear. And as for the honour of journalism, we are happy to think that it is much safer in our keeping than in that of Mr. Elmore. Information is published in our columns for the interest of our readers, and we have, of course, no concern whatever whether it is freely copied or sparsely copied into City papers of a certain kind or an uncertain kind. Mr. Elmore's references to our knowledge of the history of the electro-metallurgy of zinc, or the precautions which an editor of a respectable journal is supposed to take to satisfy himself of the truth of statements made by his correspondents are unnecessary. Mr. Watt's statements were signed by Mr. Watt. They are not our statements. Mr. Elmore's statements are signed by Mr. Elmore, but their publication in our Correspondence columns does not imply that we have examined them in detail and are prepared to vouch for their correctness. Mr. Elmore further says that we have often promised revelations as to the validity of the Elmore patents. We are not aware of having made any promises in this respect which have not been performed. On the subject of the copper companies, Mr. Elmore says his mouth is practically closed by his directors. It is, perhaps, unfortunate that some other authority had not intervened to prevent Mr. Elmore opening his mouth so widely as he has done in his letter. Curiously enough, there is seldom any restriction on statements of an indefinite but favourable character from the Elmore interest. It is only when information of a definite and practical nature is wanted that those who are in a position to give it find their mouths practically closed by their directors. Mr. Elmore draws our attention to the fact that he is a very large holder of shares in various Elmore Companies, and desires us to inform our readers that the *actual* vendors and members of the Elmore family to-day hold more shares in the companies than ever they did. Inconclusive as those statements are, we regard the information with satisfaction. Mr. Elmore will observe that we have complied with his request and have given equal prominence to his diatribe as to that of Mr. Watt. We invite Mr. Watt to make in a future issue any comments upon this letter which may elucidate the facts, and we think that Mr. Elmore would be well advised to take advice as he suggests.—EDS. ELEC. REV.]

Manganese in Cells of the Leclanché Type.

In continuation of Mr. Nash's experience of using cells of the Leclanché type without peroxide of manganese, which is so ably dealt with in your issue of the 3rd inst., I think that it may interest your readers to hear that this very form of cells is being extensively used in Denmark for *telegraphic* purposes, and with every success. In one particular office, where an immense traffic is passing throughout the 24 hours, and where fast speed Wheatstone automatic instruments are incessantly at work, from eight o'clock in the morning till twelve o'clock at night, several hundred Leclanché cells, with *crushed coke only surrounding the carbon plates*, do all the work and give entire satisfaction. Every two or three months all the cells are overhauled, cleaned, &c., &c.; but apart from such occasional renewal nothing is done, nor does it appear that any appreciable polarisation or falling off in the E.M.F. is felt during a day's work. The circuits are 400 to 500 n.m. long, with a total resistance of about 3,000 ohms each.

There is, of course, no doubt that systematic tests would reveal that some fall does take place, and that the drop is greater than in the ordinary cell where manganese is used; but the fact remains that the cells keep up wonderfully well, and that no inconvenience is felt from having discontinued the employment of the so much valued depolarising agent, peroxide of manganese.

I am not aware of any quantitative information having been obtained, and I regret, therefore, to be unable to supply any tests or curves.

P. Chr. Dresing, M.Inst.E.E.

April 13th, 1891.